FIG. 1

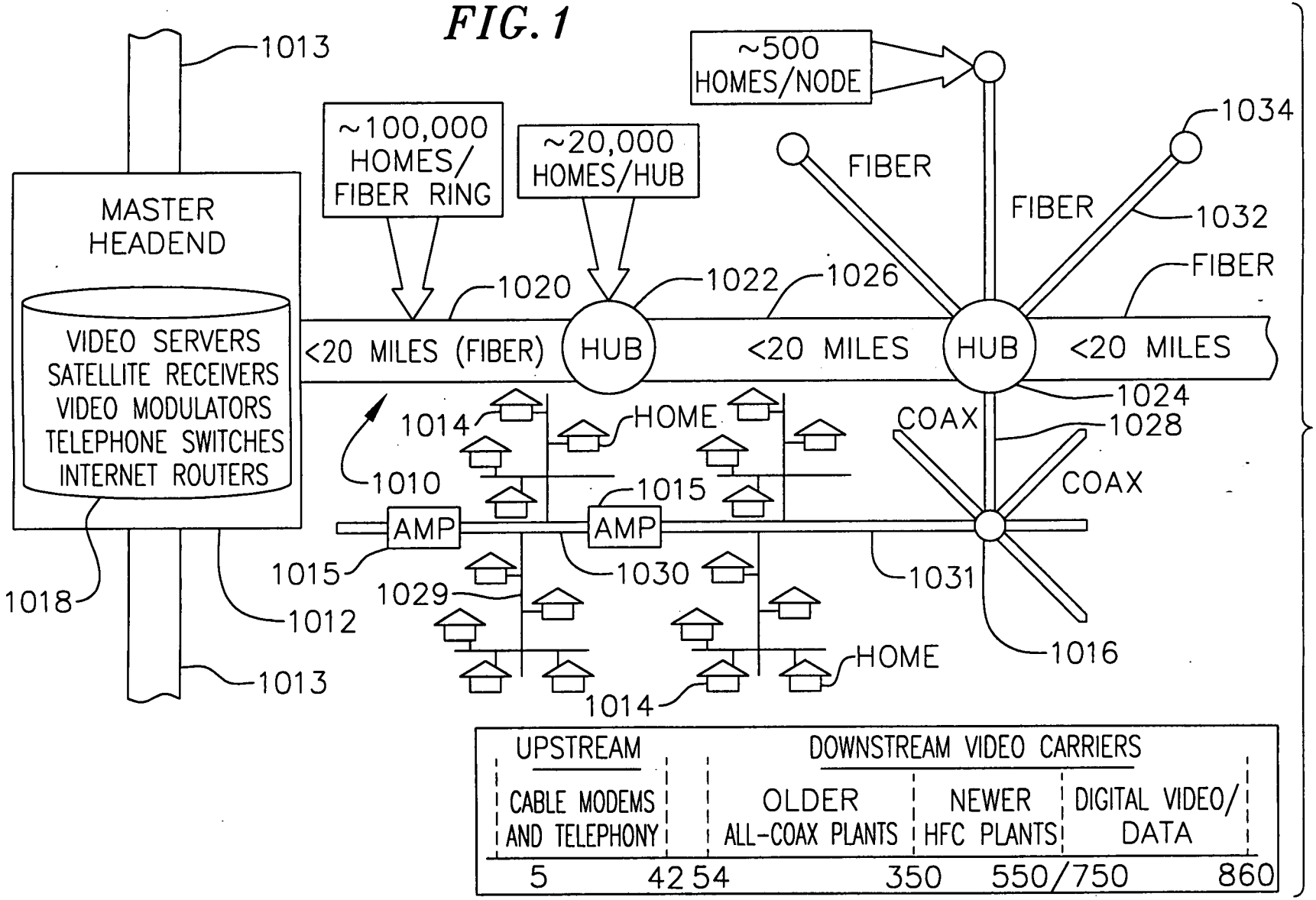

1013
MASTER HEADEND
VIDEO SERVERS
SATELLITE RECEIVERS
VIDEO MODULATORS
TELEPHONE SWITCHES
INTERNET ROUTERS
1018
1012
1013
~100,000 HOMES/ FIBER RING
~20,000 HOMES/HUB
~500 HOMES/NODE
1020
1022
1026
1034
FIBER
FIBER
1032
FIBER
<20 MILES (FIBER)
HUB
<20 MILES
HUB
<20 MILES
1024
1028
COAX
COAX
1014
HOME
1010
1015
AMP
AMP
1015
1030
1031
1029
1016
HOME
1014
UPSTREAM
DOWNSTREAM VIDEO CARRIERS
CABLE MODEMS AND TELEPHONY
OLDER ALL-COAX PLANTS
NEWER HFC PLANTS
DIGITAL VIDEO/ DATA
5
42
54
350
550/750
860

FIG.2

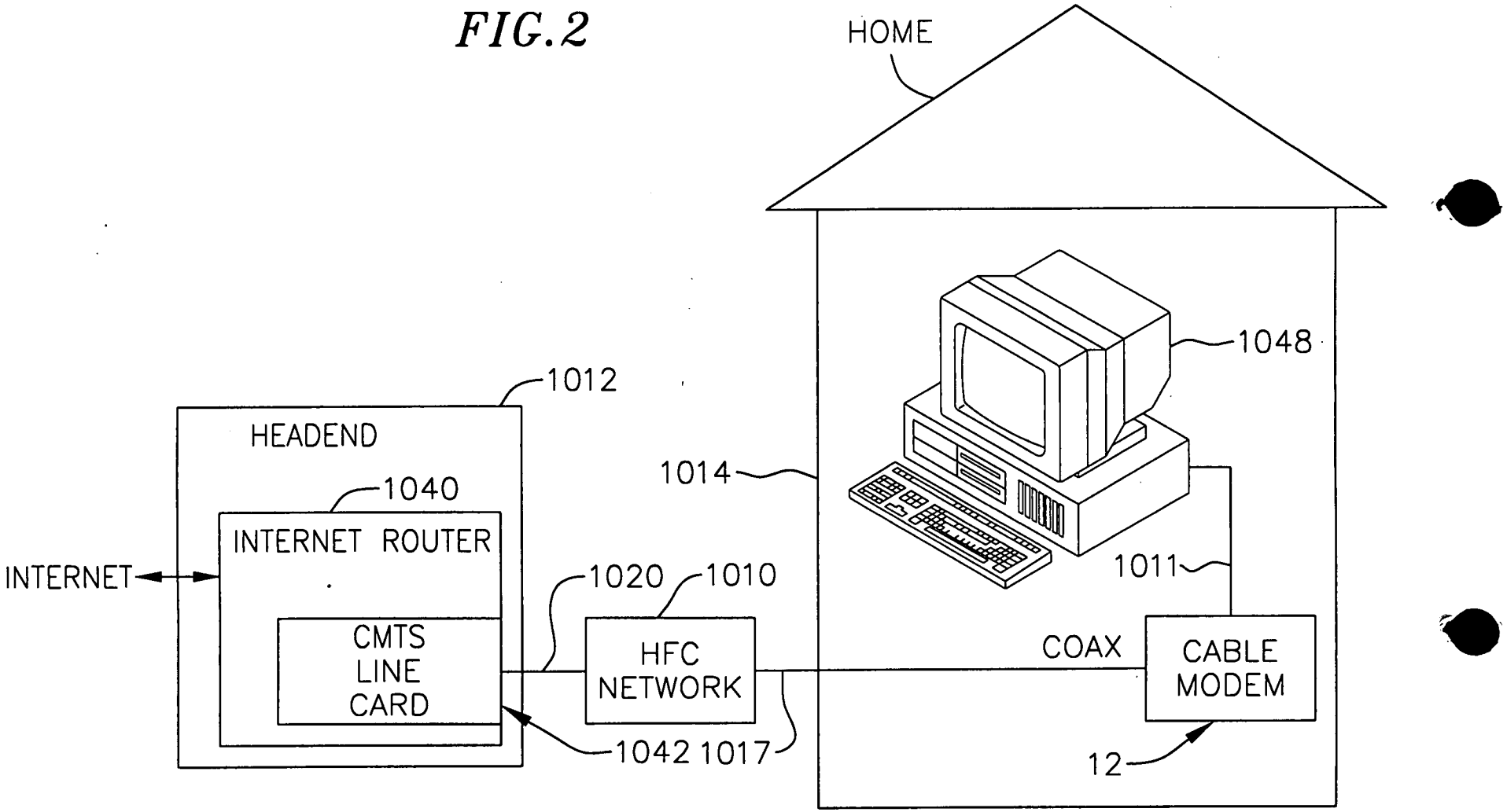

HOME
1048
1012
HEADEND
1014
1040
INTERNET ROUTER
INTERNET
1020
1010
1011
CMTS
LINE
CARD
HFC
NETWORK
COAX
CABLE
MODEM
1042
1017
12

FIG.3

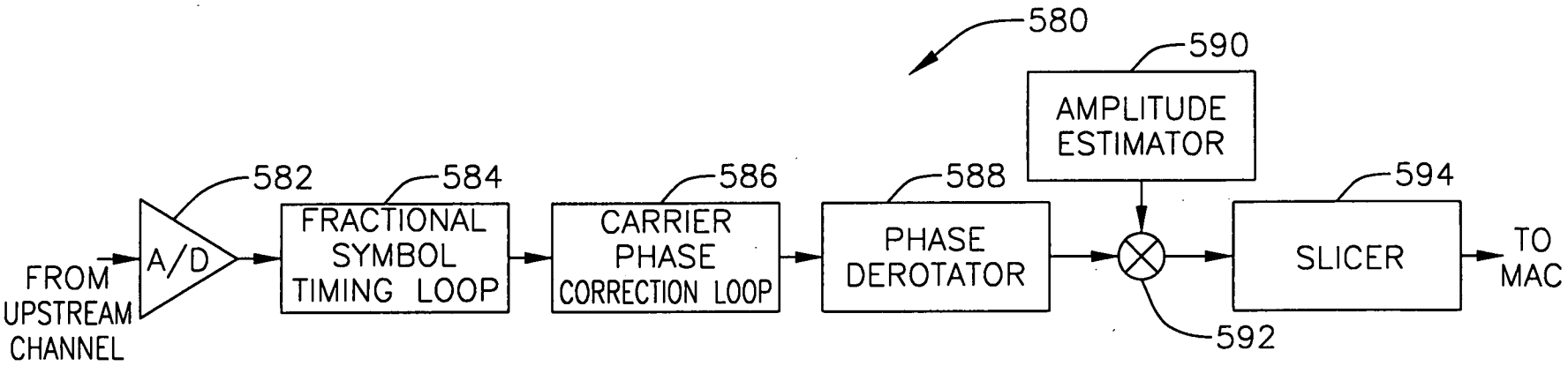

580
590
AMPLITUDE ESTIMATOR
582
584
586
588
594
FROM UPSTREAM CHANNEL
A/D
FRACTIONAL SYMBOL TIMING LOOP
CARRIER PHASE CORRECTION LOOP
PHASE DEROTATOR
SLICER
TO MAC
592

FIG.4

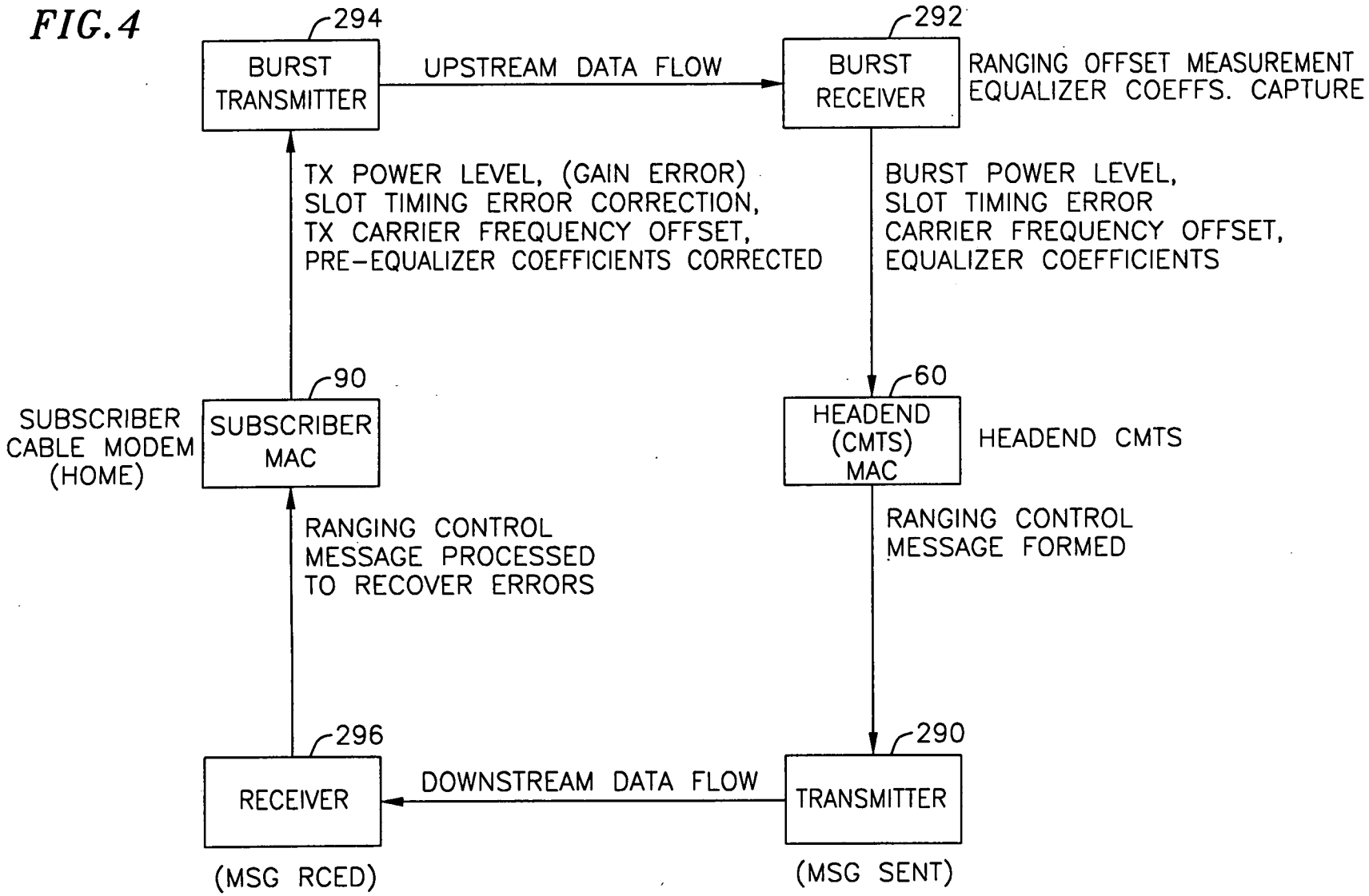

294
BURST TRANSMITTER
UPSTREAM DATA FLOW
292
BURST RECEIVER
RANGING OFFSET MEASUREMENT
EQUALIZER COEFFS. CAPTURE
TX POWER LEVEL, (GAIN ERROR)
SLOT TIMING ERROR CORRECTION,
TX CARRIER FREQUENCY OFFSET,
PRE-EQUALIZER COEFFICIENTS CORRECTED
BURST POWER LEVEL,
SLOT TIMING ERROR
CARRIER FREQUENCY OFFSET,
EQUALIZER COEFFICIENTS
90
SUBSCRIBER CABLE MODEM (HOME)
SUBSCRIBER MAC
60
HEADEND (CMTS) MAC
HEADEND CMTS
RANGING CONTROL
MESSAGE PROCESSED
TO RECOVER ERRORS
RANGING CONTROL
MESSAGE FORMED
296
RECEIVER
DOWNSTREAM DATA FLOW
290
TRANSMITTER
(MSG RCED)
(MSG SENT)

FIG.5A

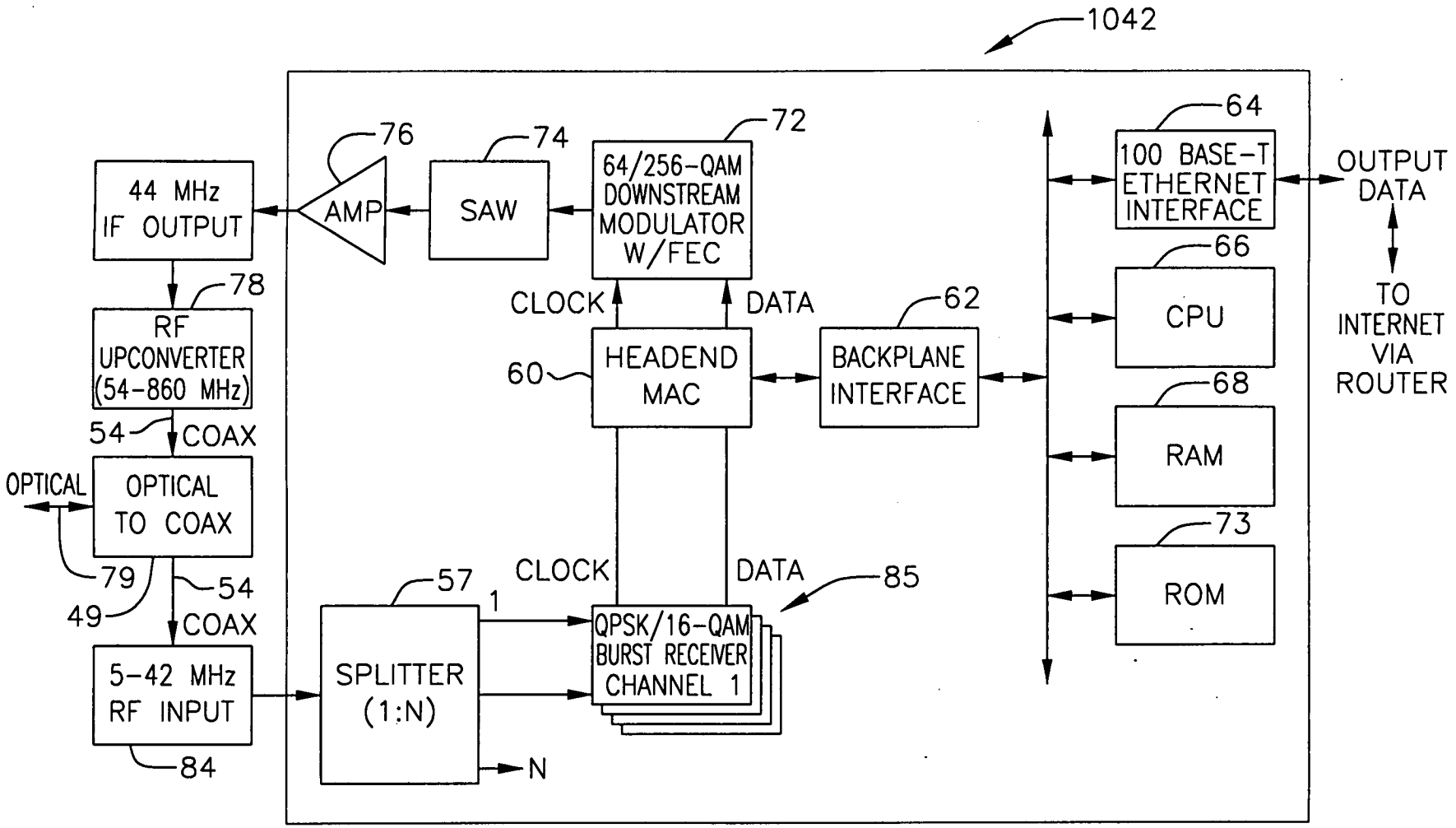

1042
64
100 BASE-T ETHERNET INTERFACE
OUTPUT DATA
TO INTERNET VIA ROUTER
66
CPU
68
RAM
73
ROM
72
64/256-QAM DOWNSTREAM MODULATOR W/FEC
74
SAW
76
AMP
44 MHz IF OUTPUT
78
RF UPCONVERTER (54-860 MHz)
54
COAX
OPTICAL
OPTICAL TO COAX
79
49
54
COAX
5-42 MHz RF INPUT
84
CLOCK
DATA
62
BACKPLANE INTERFACE
60
HEADEND MAC
CLOCK
DATA
85
57
1
SPLITTER (1:N)
QPSK/16-QAM BURST RECEIVER CHANNEL 1
N

FIG.5B

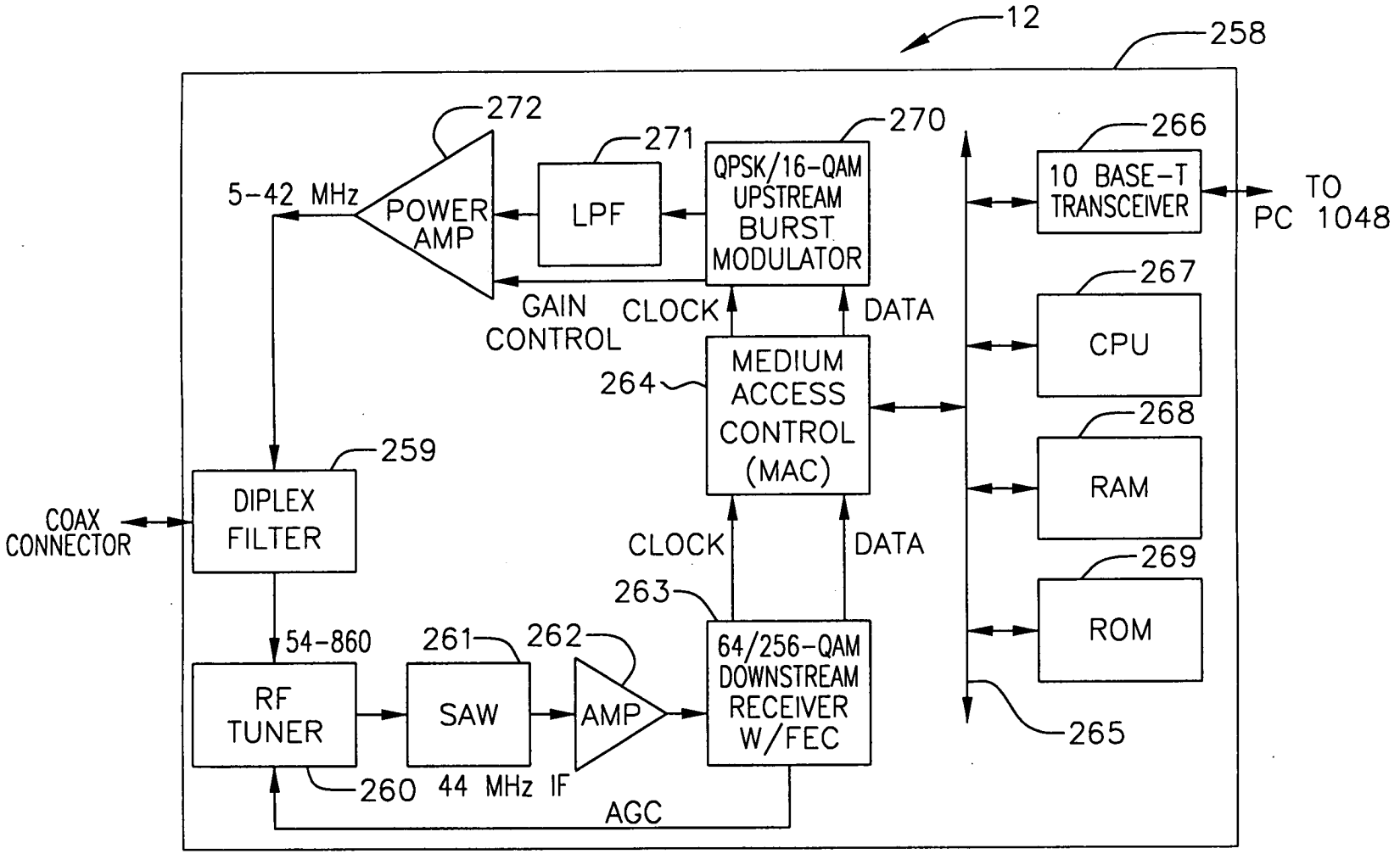

12
258
272
271
270
266
5-42 MHz
POWER AMP
LPF
QPSK/16-QAM UPSTREAM BURST MODULATOR
10 BASE-T TRANSCEIVER
TO PC 1048
GAIN CONTROL
CLOCK
DATA
267
CPU
264
MEDIUM ACCESS CONTROL (MAC)
268
RAM
259
DIPLEX FILTER
COAX CONNECTOR
CLOCK
DATA
269
263
ROM
54-860
261
262
RF TUNER
SAW
AMP
64/256-QAM DOWNSTREAM RECEIVER W/FEC
265
260
44 MHz IF
AGC

FIG.6A

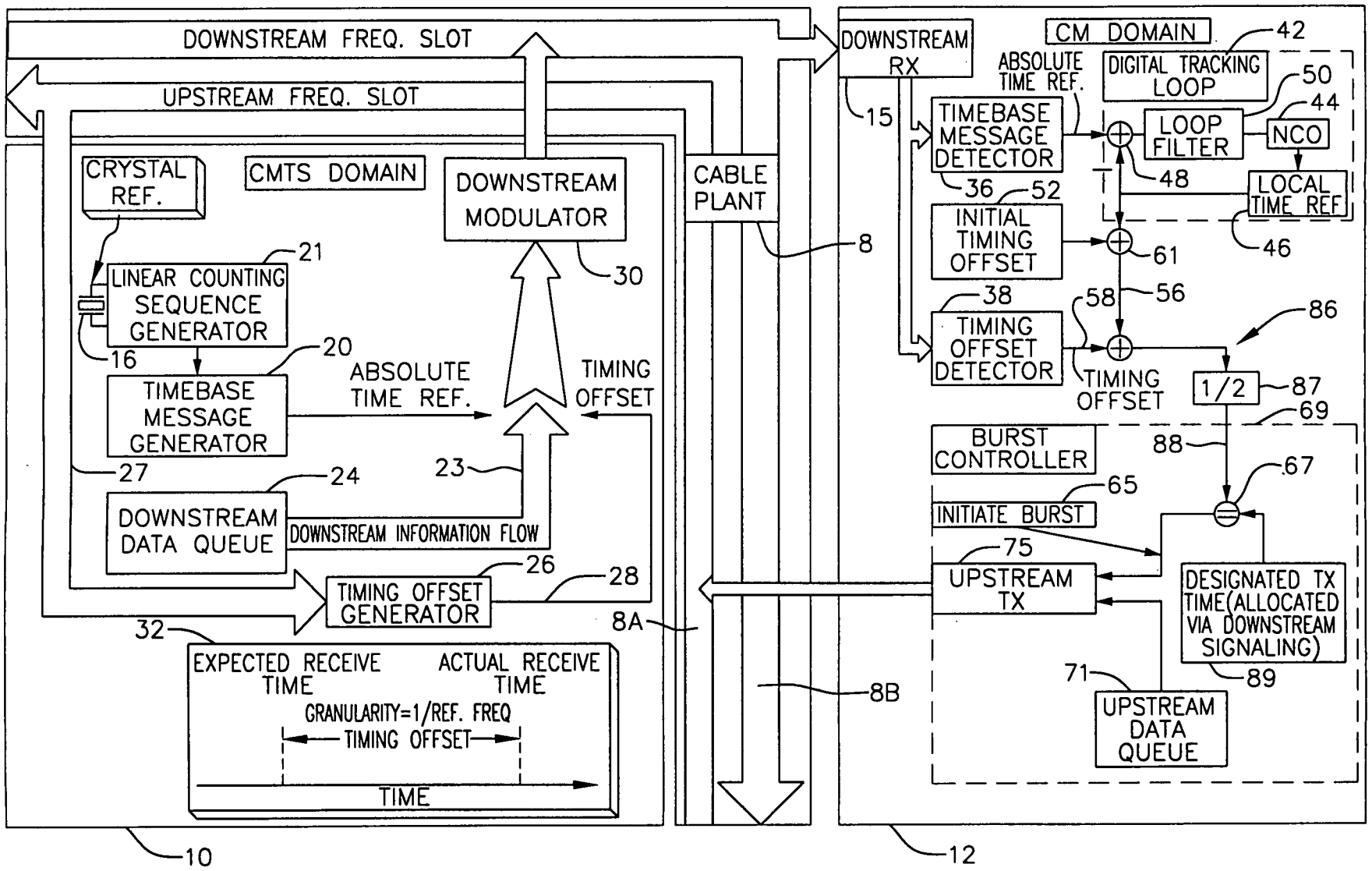
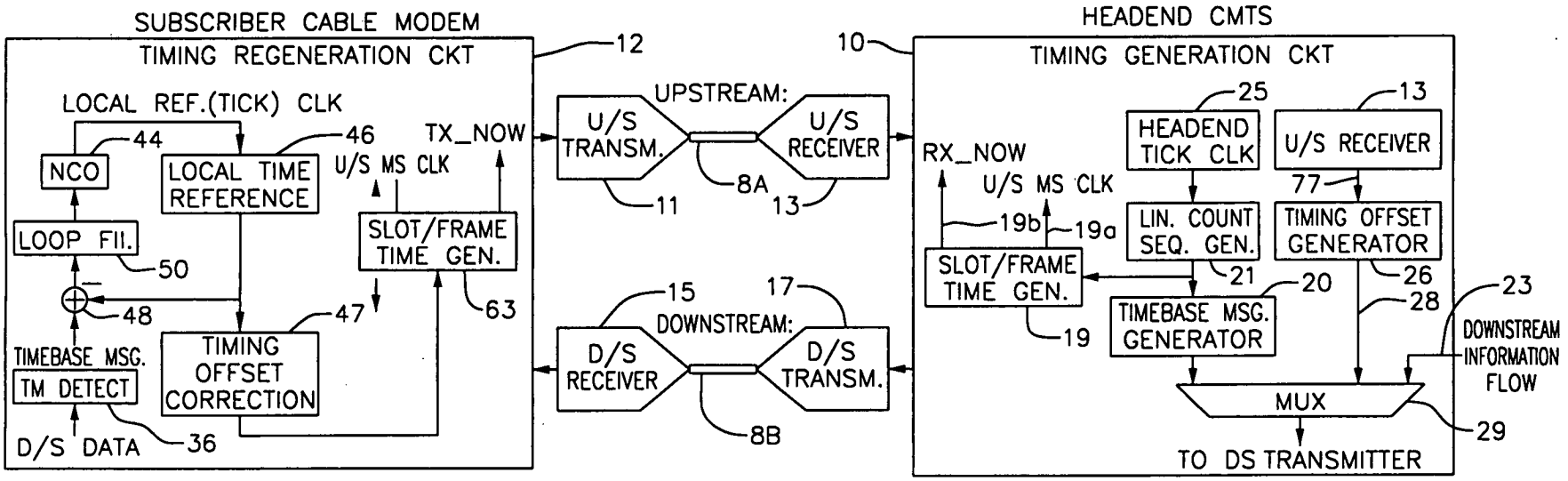

DOWNSTREAM FREQ. SLOT
UPSTREAM FREQ. SLOT
CRYSTAL REF.
CMTS DOMAIN
DOWNSTREAM MODULATOR
CABLE PLANT
DOWNSTREAM RX
CM DOMAIN
42
ABSOLUTE TIME REF.
DIGITAL TRACKING LOOP
50
44
15
TIMEBASE MESSAGE DETECTOR
LOOP FILTER
NCO
48
LOCAL TIME REF
36
52
INITIAL TIMING OFFSET
61
46
21
LINEAR COUNTING SEQUENCE GENERATOR
30
8
38
58
56
86
16
20
TIMEBASE MESSAGE GENERATOR
ABSOLUTE TIME REF.
TIMING OFFSET
TIMING OFFSET DETECTOR
TIMING OFFSET
1/2
87
69
BURST CONTROLLER
88
27
24
23
67
65
DOWNSTREAM DATA QUEUE
DOWNSTREAM INFORMATION FLOW
INITIATE BURST
75
26
28
UPSTREAM TX
DESIGNATED TX TIME(ALLOCATED VIA DOWNSTREAM SIGNALING)
TIMING OFFSET GENERATOR
8A
32
89
71
EXPECTED RECEIVE TIME
ACTUAL RECEIVE TIME
8B
UPSTREAM DATA QUEUE
GRANULARITY=1/REF. FREQ
TIMING OFFSET
TIME
10
12

FIG.6B


SUBSCRIBER CABLE MODEM
TIMING REGENERATION CKT
12
LOCAL REF.(TICK) CLK
44
NCO
46
LOCAL TIME REFERENCE
TX_NOW
U/S MS CLK
LOOP FII.
50
SLOT/FRAME TIME GEN.
48
47
63
TIMEBASE MSG.
TM DETECT
TIMING OFFSET CORRECTION
D/S DATA
36
UPSTREAM:
U/S TRANSM.
U/S RECEIVER
8A
11
13
15
17
DOWNSTREAM:
D/S RECEIVER
D/S TRANSM.
8B
10
HEADEND CMTS
TIMING GENERATION CKT
25
HEADEND TICK CLK
13
U/S RECEIVER
77
RX_NOW
U/S MS CLK
19b
19a
LIN. COUNT SEQ. GEN.
TIMING OFFSET GENERATOR
SLOT/FRAME TIME GEN.
21
20
26
23
28
TIMEBASE MSG. GENERATOR
19
DOWNSTREAM INFORMATION FLOW
MUX
29
TO DS TRANSMITTER

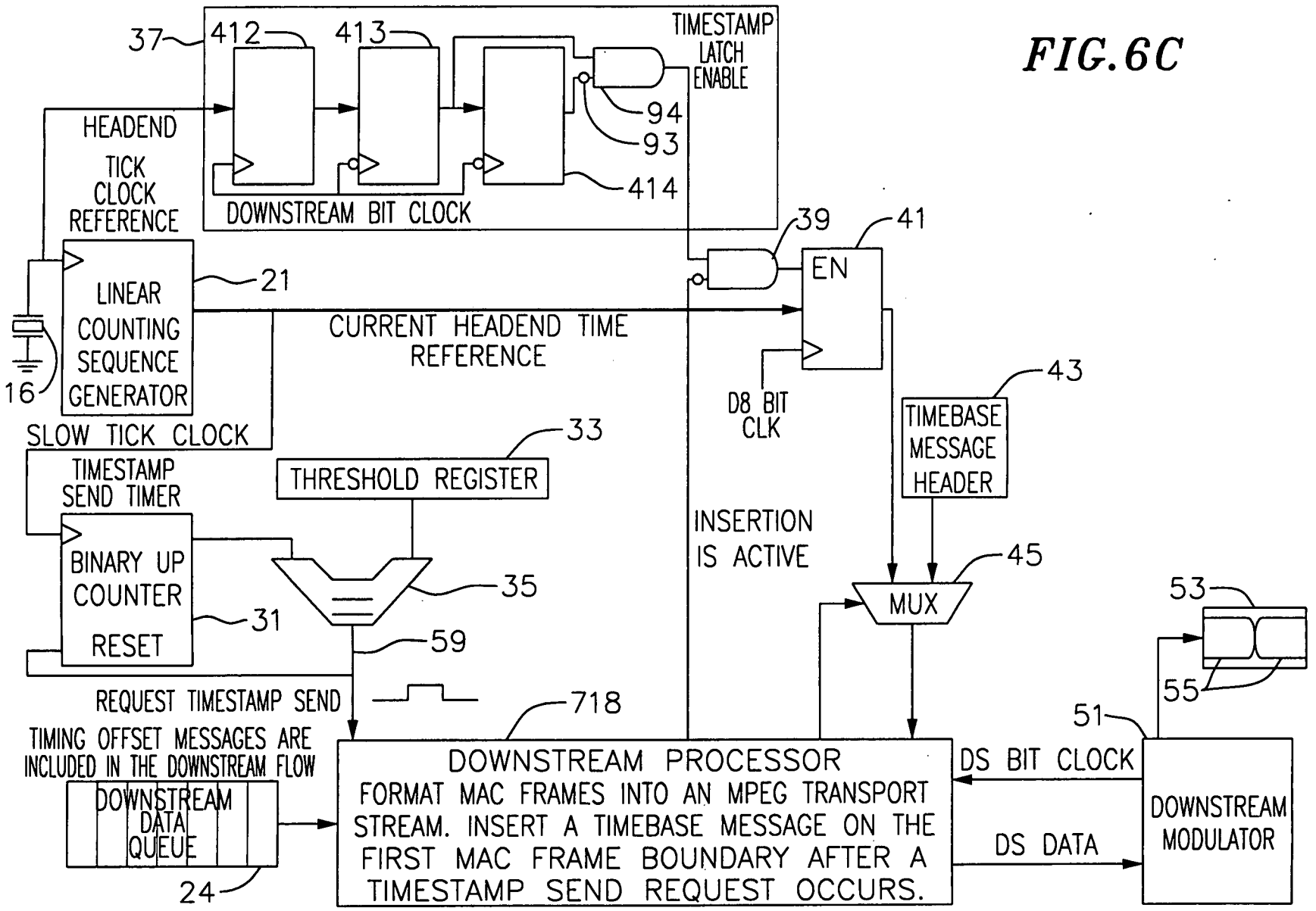

37
412
413
TIMESTAMP LATCH ENABLE
94
93
414
HEADEND TICK CLOCK REFERENCE
DOWNSTREAM BIT CLOCK
39
41
EN
LINEAR COUNTING SEQUENCE GENERATOR
21
16
CURRENT HEADEND TIME REFERENCE
D8 BIT CLK
43
TIMEBASE MESSAGE HEADER
SLOW TICK CLOCK
33
THRESHOLD REGISTER
TIMESTAMP SEND TIMER
INSERTION IS ACTIVE
BINARY UP COUNTER
RESET
31
35
45
MUX
53
55
59
REQUEST TIMESTAMP SEND
718
51
TIMING OFFSET MESSAGES ARE INCLUDED IN THE DOWNSTREAM FLOW
DOWNSTREAM DATA QUEUE
24
DOWNSTREAM PROCESSOR
FORMAT MAC FRAMES INTO AN MPEG TRANSPORT STREAM. INSERT A TIMEBASE MESSAGE ON THE FIRST MAC FRAME BOUNDARY AFTER A TIMESTAMP SEND REQUEST OCCURS.
DS BIT CLOCK
DS DATA
DOWNSTREAM MODULATOR

FIG.6C

FIG. 6D

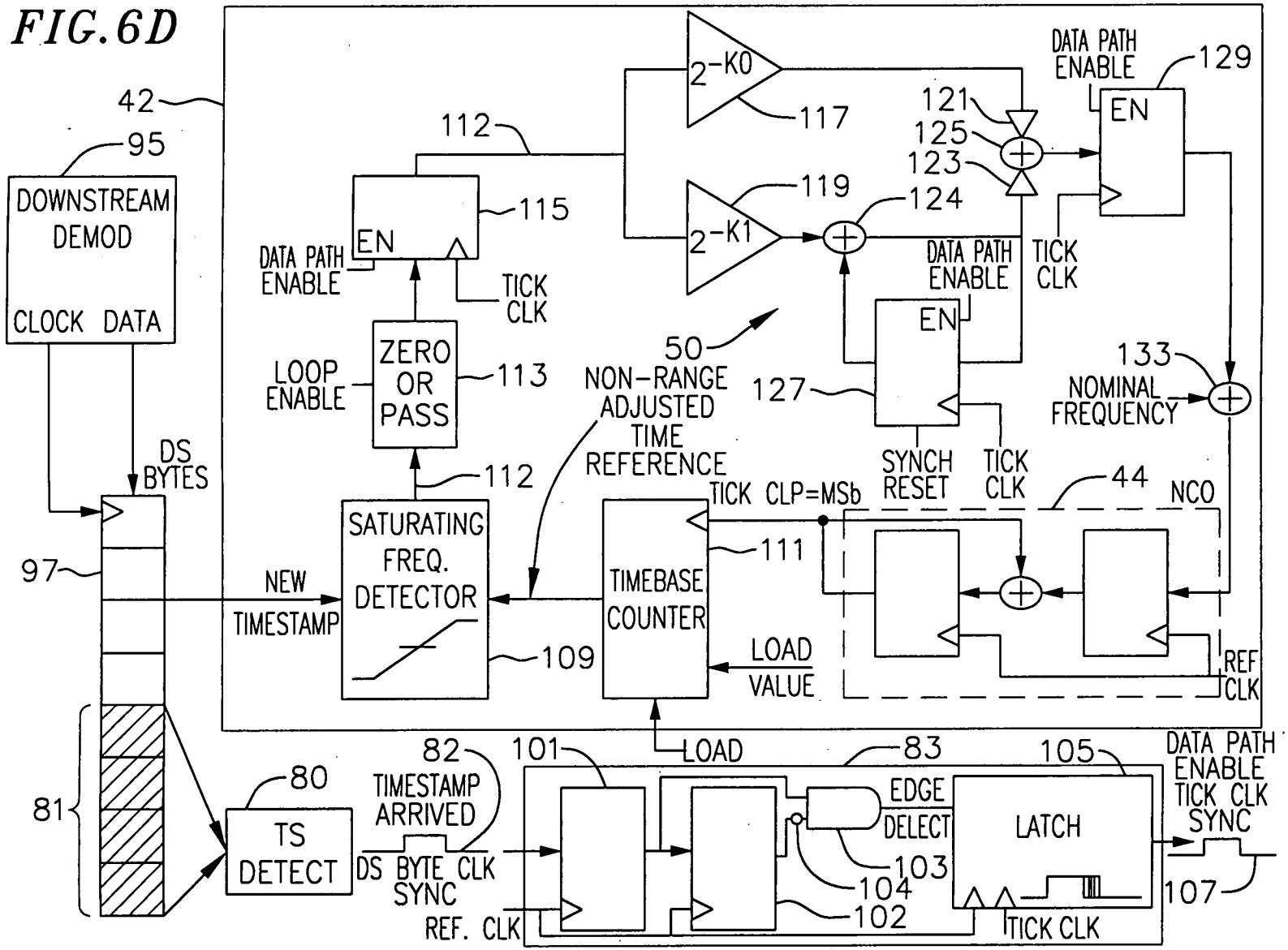

42
95
DOWNSTREAM DEMOD
CLOCK DATA
DS BYTES
97
81
80
TS DETECT
82
TIMESTAMP ARRIVED
DS BYTE CLK SYNC
REF. CLK
NEW TIMESTAMP
SATURATING FREQ. DETECTOR
109
112
ZERO OR PASS
113
LOOP ENABLE
115
EN
DATA PATH ENABLE
TICK CLK
2-K0
117
2-K1
119
112
121
125
123
124
50
NON-RANGE ADJUSTED TIME REFERENCE
TIMEBASE COUNTER
111
TICK CLP=MSb
LOAD VALUE
LOAD
127
EN
DATA PATH ENABLE
SYNCH RESET
TICK CLK
129
EN
DATA PATH ENABLE
TICK CLK
133
NOMINAL FREQUENCY
44
NCO
REF CLK
101
83
105
EDGE DELECT
103
104
102
LATCH
TICK CLK
DATA PATH ENABLE TICK CLK SYNC
107

FIG.6E

UPDATE RATE	COARSE COEFFS	FINE COEFFICIENTS
1kHz(1ms)	$K0=2^{-11}$ $K1=2^{-15}$ (BW=50Hz)	$K0=2^{-16}$ $K1=2^{-25}$ (BW=1Hz)
300Hz(3.3ms)	$K0=2^{-12}$ $K1=2^{-15}$ (BW=20Hz)	$K0=2^{-16}$ $K1=2^{-23}$ (BW=1Hz)
100Hz(10ms)	$K0=2^{-13}$ $K1=2^{-16}$ (BW=10Hz)	$K0=2^{-16}$ $K1=2^{-22}$ (BW=1Hz)
50Hz(20ms)	$K0=2^{-14}$ $K1=2^{-17}$ (BW=5Hz)	$K0=2^{-16}$ $K1=2^{-21}$ (BW=1Hz)
30Hz(33ms)	$K0=2^{-15}$ $K1=2^{-18}$ (BW=3Hz)	$K0=2^{-17}$ $K1=2^{-21}$ (BW=1Hz)
10Hz(100ms)	$K0=2^{-17}$ $K1=2^{-20}$ (BW=1Hz)	$K0=2^{-17}$ $K1=2^{-20}$ (BW=1Hz)
5Hz(200ms)	$K0=2^{-18}$ $K1=2^{-20}$ (BW=1Hz)	$K0=2^{-18}$ $K1=2^{-20}$ (BW=1Hz)

US005502762A

FIG. 7A

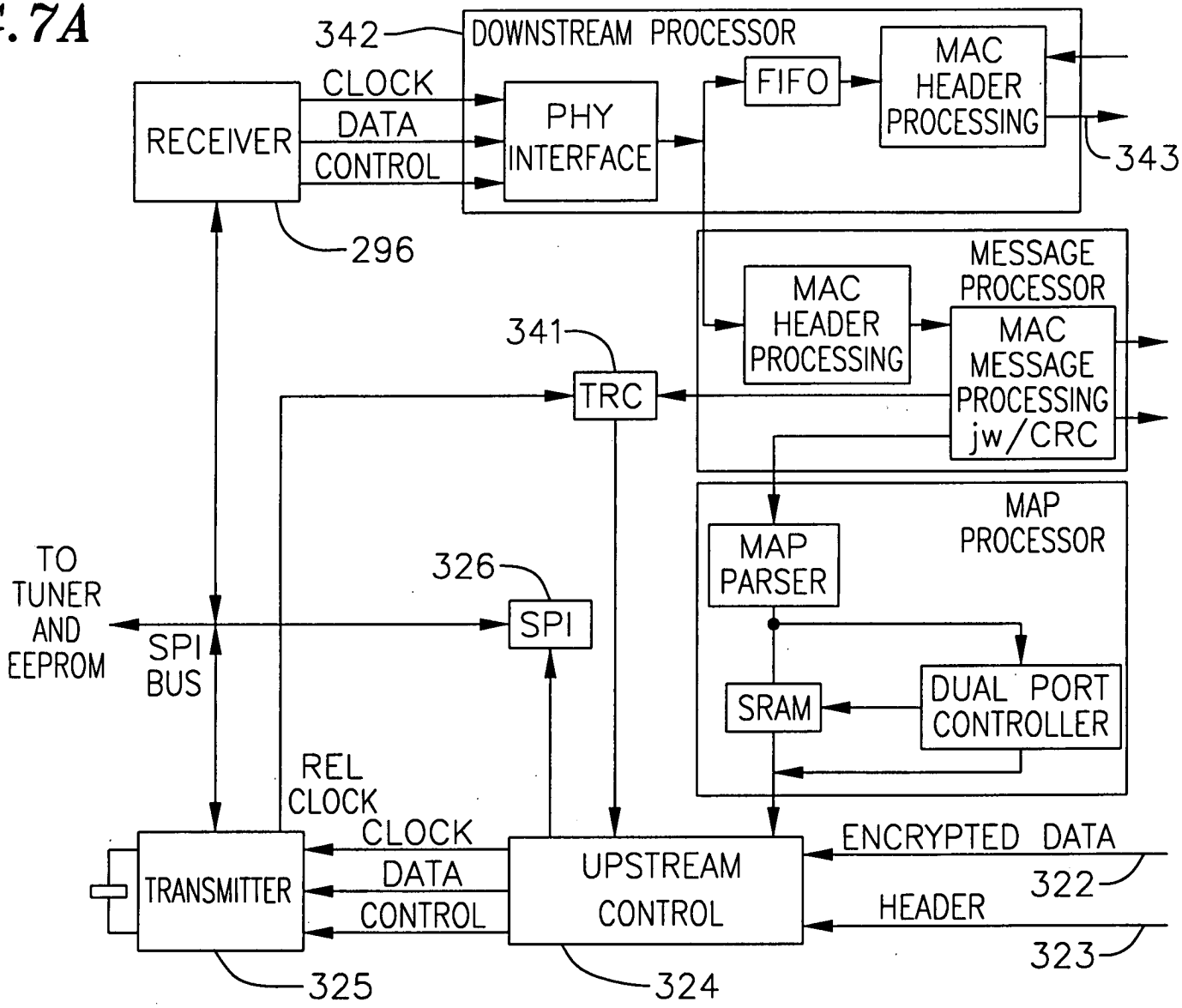

342
DOWNSTREAM PROCESSOR
CLOCK
DATA
CONTROL
RECEIVER
PHY INTERFACE
FIFO
MAC HEADER PROCESSING
343
296
MESSAGE PROCESSOR
MAC HEADER PROCESSING
MAC MESSAGE PROCESSING jw/CRC
341
TRC
MAP PROCESSOR
MAP PARSER
TO TUNER AND EEPROM
326
SPI
SPI BUS
SRAM
DUAL PORT CONTROLLER
REL CLOCK
CLOCK
DATA
CONTROL
TRANSMITTER
UPSTREAM CONTROL
ENCRYPTED DATA
322
HEADER
323
325
324

FIG. 7B

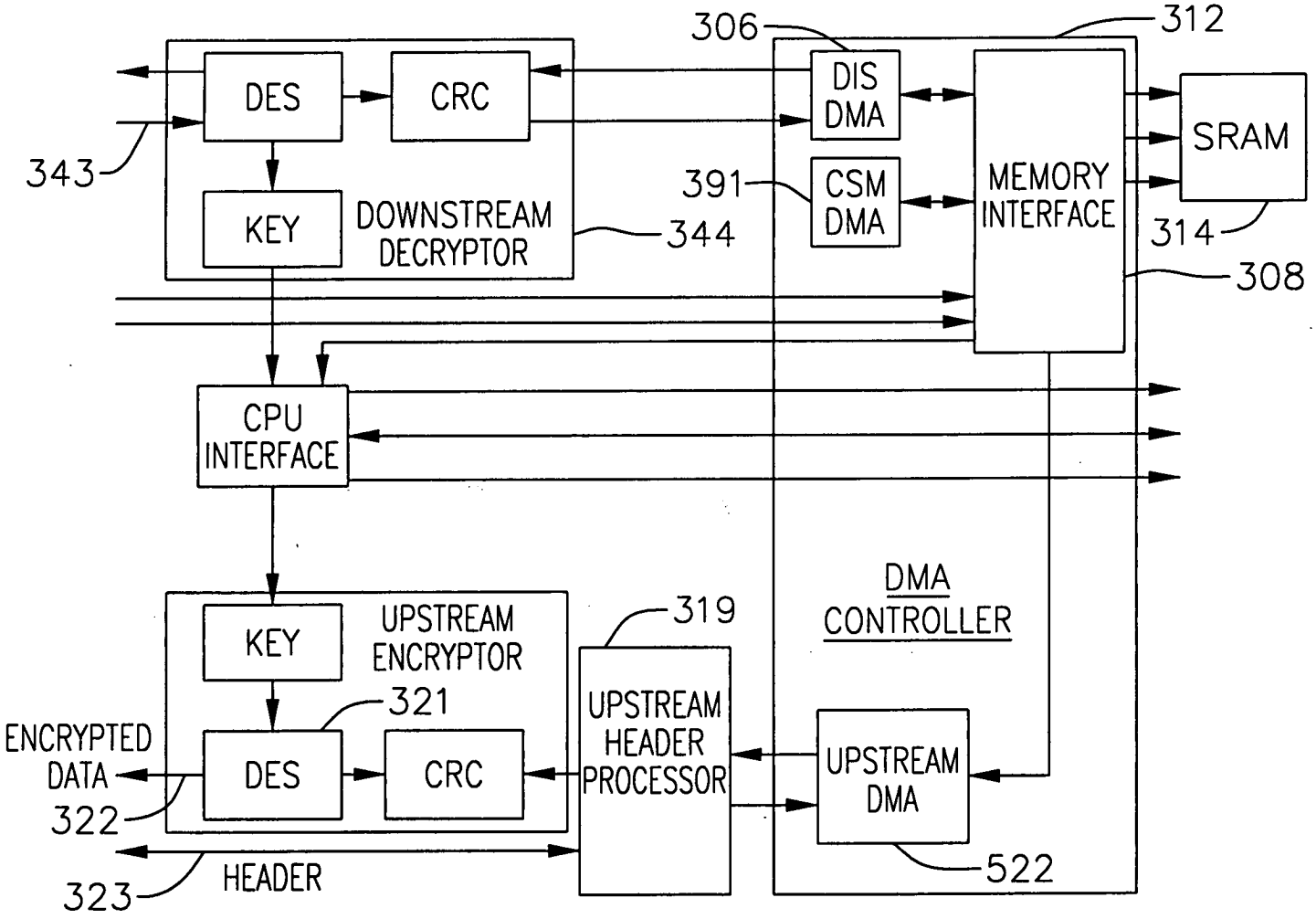

306
312
DES
CRC
DIS DMA
SRAM
343
391
CSM DMA
MEMORY INTERFACE
KEY
DOWNSTREAM DECRYPTOR
344
314
308
CPU INTERFACE
DMA CONTROLLER
KEY
UPSTREAM ENCRYPTOR
319
321
ENCRYPTED DATA
DES
CRC
UPSTREAM HEADER PROCESSOR
UPSTREAM DMA
322
HEADER
323
522

FIG. 8A

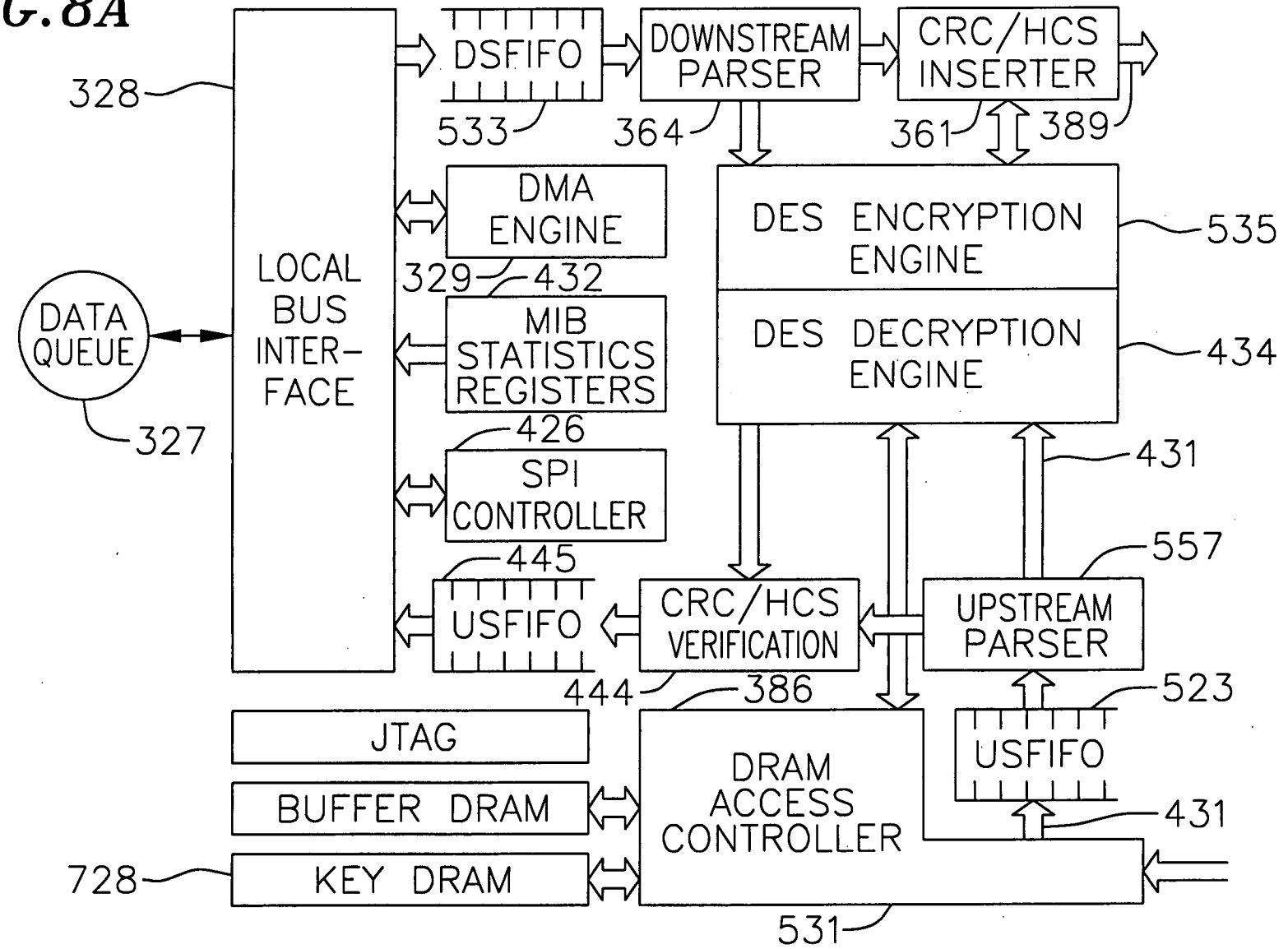

328
DSFIFO
533
DOWNSTREAM PARSER
364
CRC/HCS INSERTER
361
389
DMA ENGINE
329
432
DES ENCRYPTION ENGINE
535
DES DECRYPTION ENGINE
434
DATA QUEUE
327
LOCAL BUS INTER-FACE
MIB STATISTICS REGISTERS
426
SPI CONTROLLER
431
557
445
USFIFO
CRC/HCS VERIFICATION
UPSTREAM PARSER
444
386
523
JTAG
BUFFER DRAM
DRAM ACCESS CONTROLLER
USFIFO
431
728
KEY DRAM
531

FIG.8B

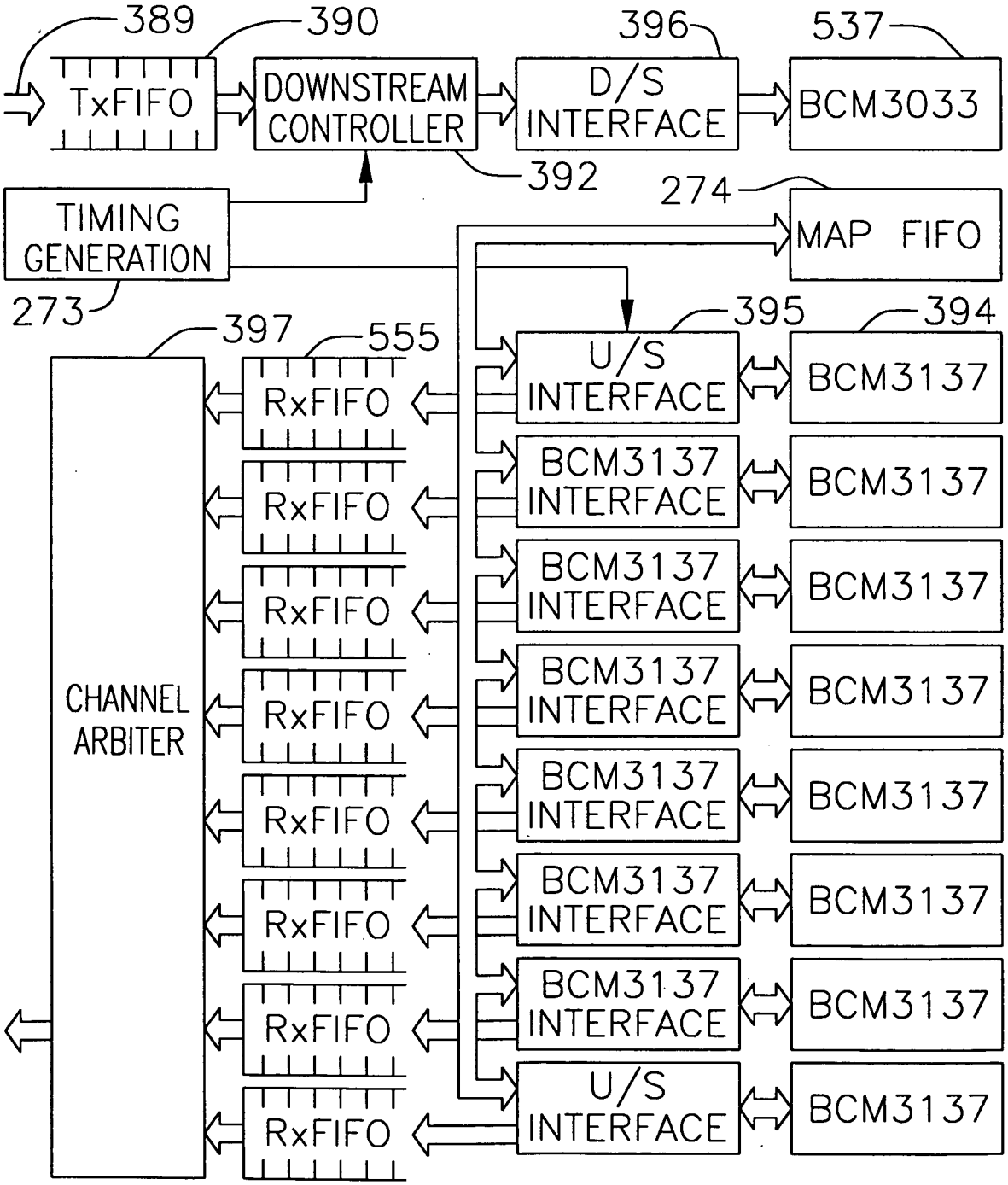

389
390
396
537
TxFIFO
DOWNSTREAM CONTROLLER
D/S INTERFACE
BCM3033
392
274
TIMING GENERATION
MAP FIFO
273
397
555
395
394
U/S INTERFACE
BCM3137
RxFIFO
BCM3137 INTERFACE
CHANNEL ARBITER

FIG. 9

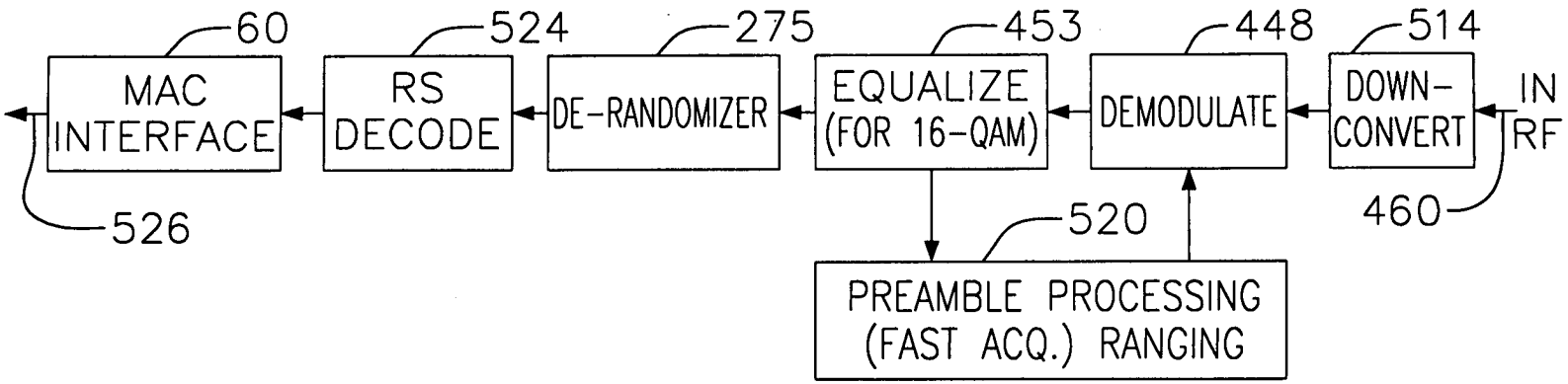

60
524
275
453
448
514
MAC INTERFACE
RS DECODE
DE-RANDOMIZER
EQUALIZE (FOR 16-QAM)
DEMODULATE
DOWN-CONVERT
IN RF
526
460
520
PREAMBLE PROCESSING (FAST ACQ.) RANGING

FIG. 10

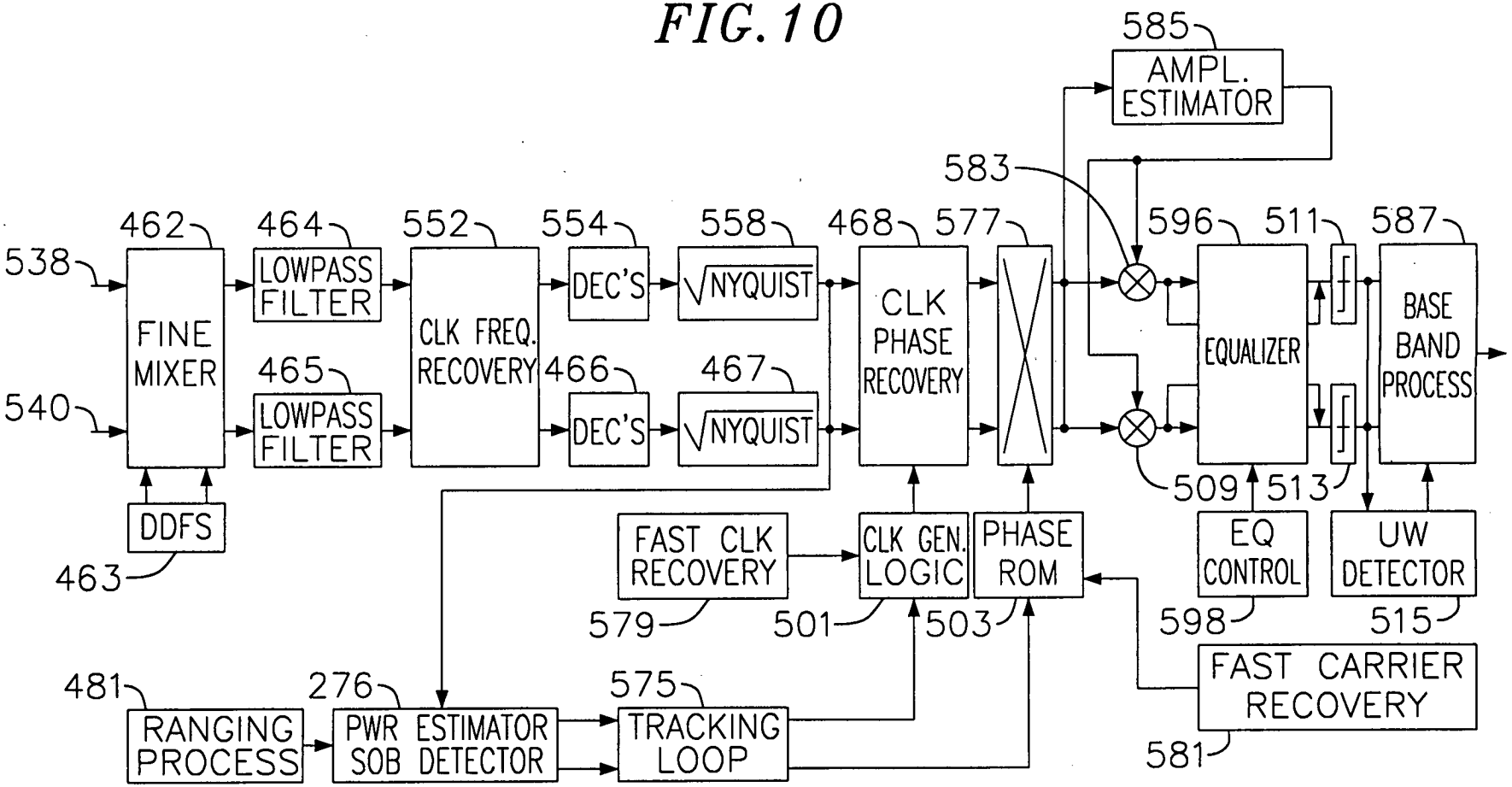

585
AMPL. ESTIMATOR
583
462
464
552
554
558
468
577
596
511
587
538
FINE MIXER
LOWPASS FILTER
CLK FREQ. RECOVERY
DEC'S
√NYQUIST
CLK PHASE RECOVERY
EQUALIZER
BASE BAND PROCESS
540
465
466
467
LOWPASS FILTER
DEC'S
√NYQUIST
509
513
DDFS
463
FAST CLK RECOVERY
CLK GEN. LOGIC
PHASE ROM
EQ CONTROL
UW DETECTOR
579
501
503
598
515
481
276
575
RANGING PROCESS
PWR ESTIMATOR SOB DETECTOR
TRACKING LOOP
FAST CARRIER RECOVERY
581

FIG. 11

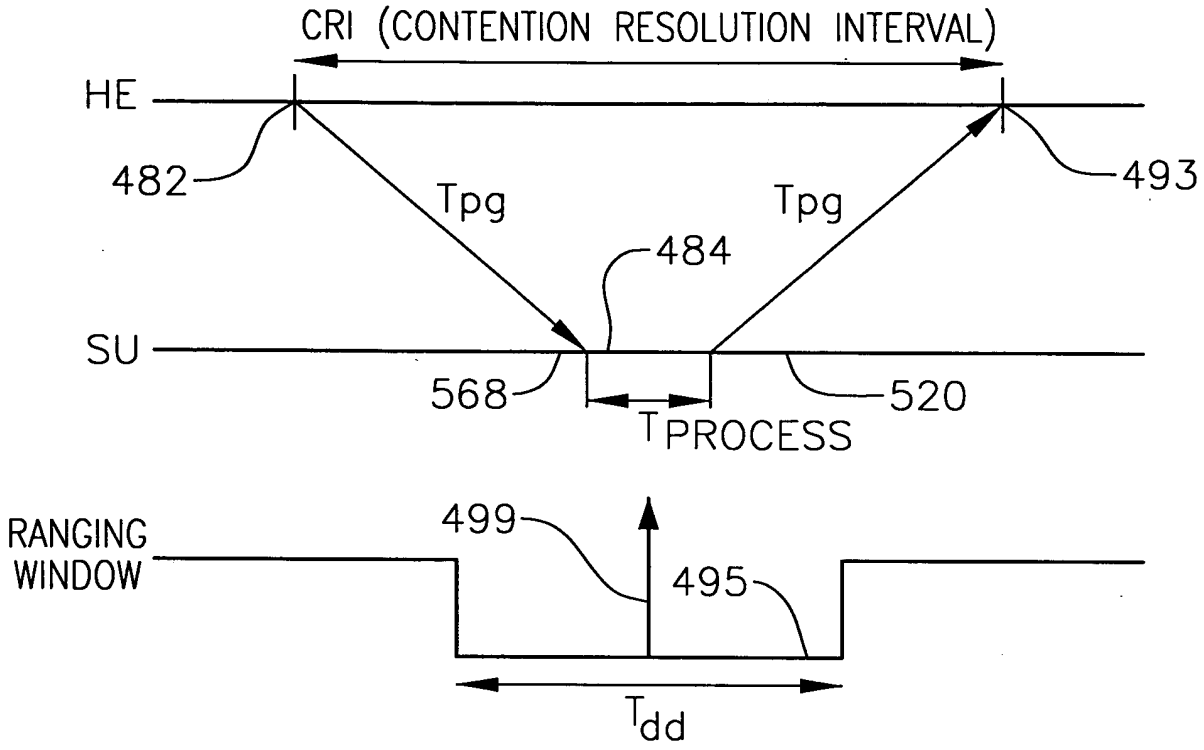

CRI (CONTENTION RESOLUTION INTERVAL)
HE
482
Tpg
Tpg
493
484
SU
568
520
TPROCESS
RANGING WINDOW
499
495
Tdd

FIG. 12

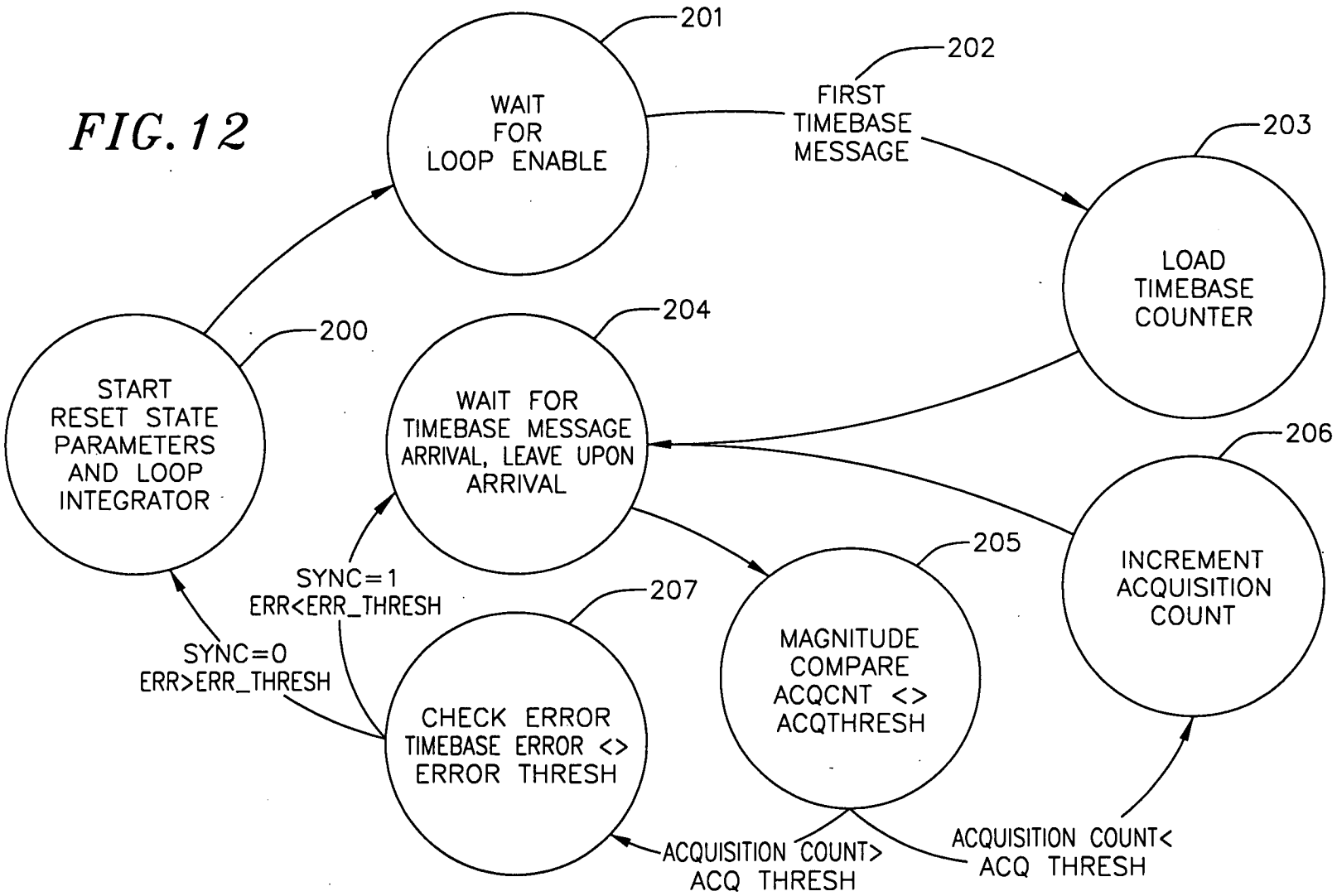
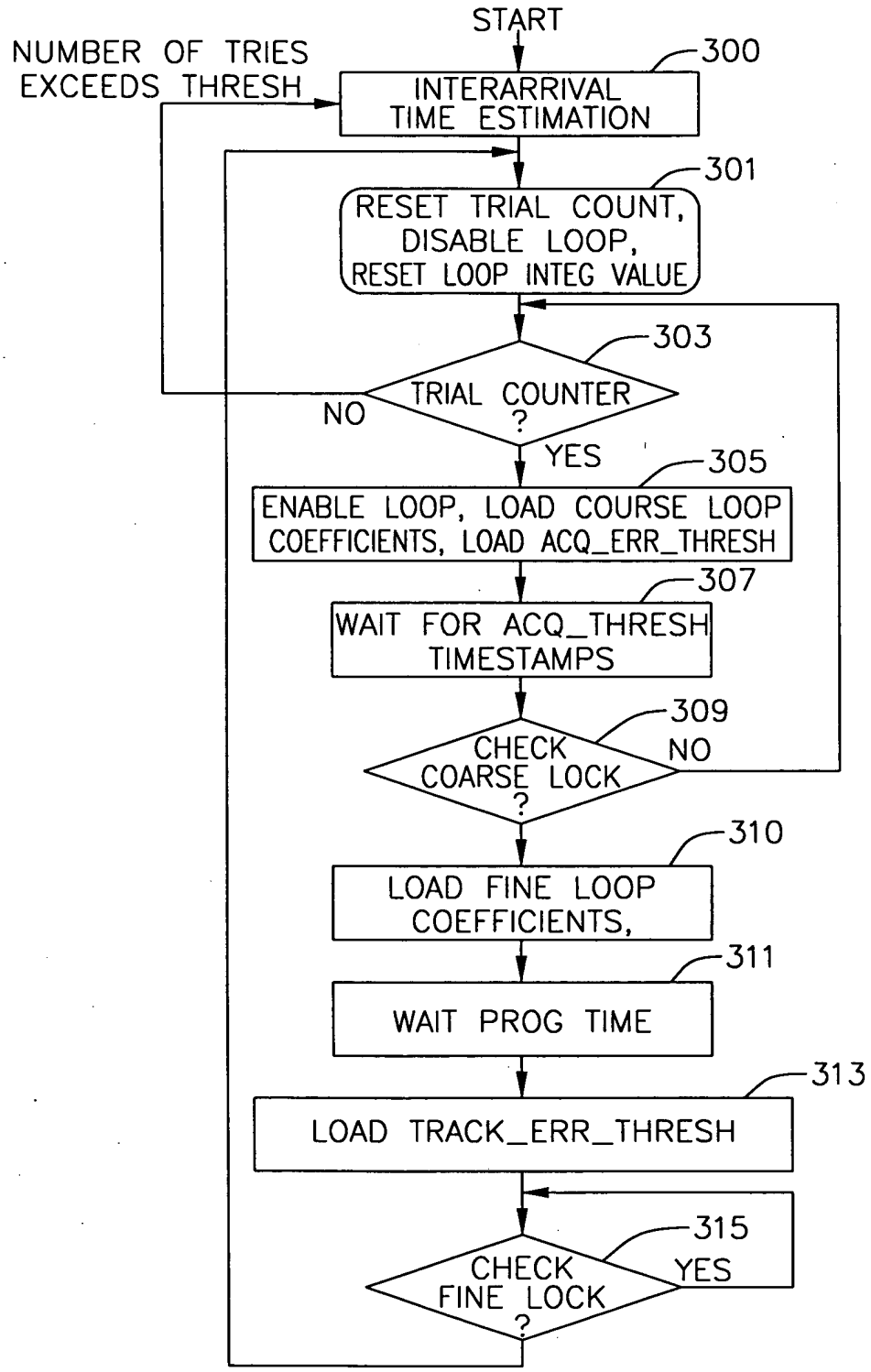

201
WAIT FOR LOOP ENABLE
202
FIRST TIMEBASE MESSAGE
203
LOAD TIMEBASE COUNTER
200
START RESET STATE PARAMETERS AND LOOP INTEGRATOR
204
WAIT FOR TIMEBASE MESSAGE ARRIVAL, LEAVE UPON ARRIVAL
206
INCREMENT ACQUISITION COUNT
205
MAGNITUDE COMPARE ACQCNT <> ACQTHRESH
SYNC=1 ERR<ERR_THRESH
207
SYNC=0 ERR>ERR_THRESH
CHECK ERROR TIMEBASE ERROR <> ERROR THRESH
ACQUISITION COUNT> ACQ THRESH
ACQUISITION COUNT< ACQ THRESH

FIG. 13



0 0 5 6 5 4 2 0 2 4 - 0 0 0 5 6 5 4 2 0

FIG. 14

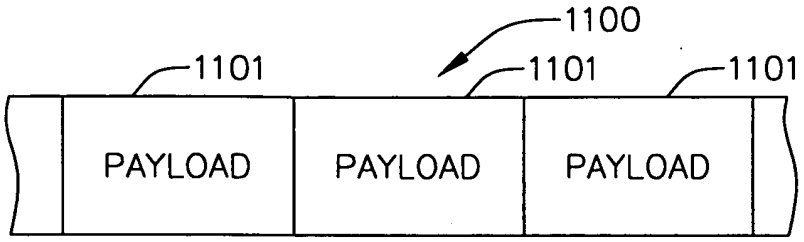


FIG. 15

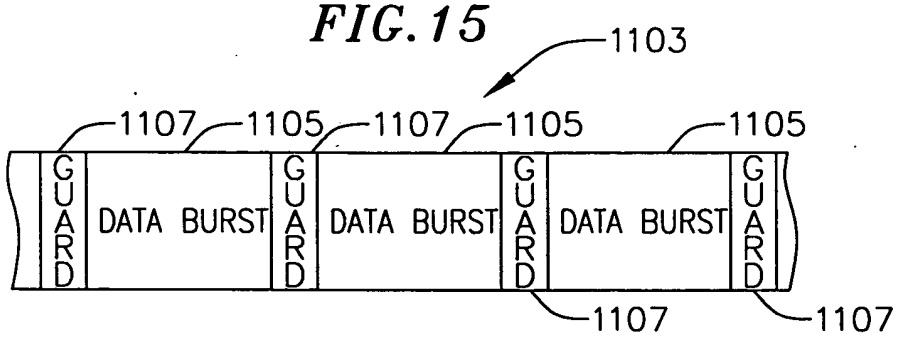


FIG. 16

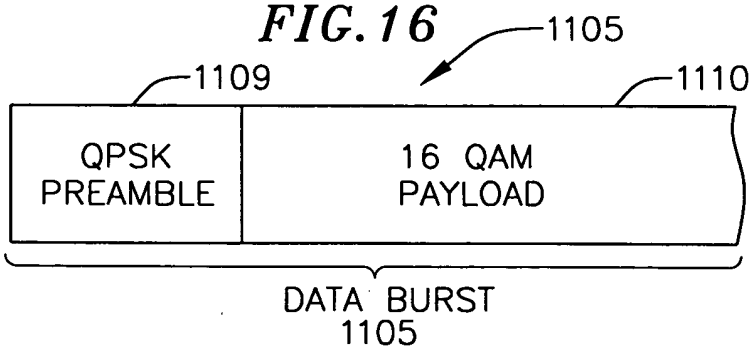


FIG. 17

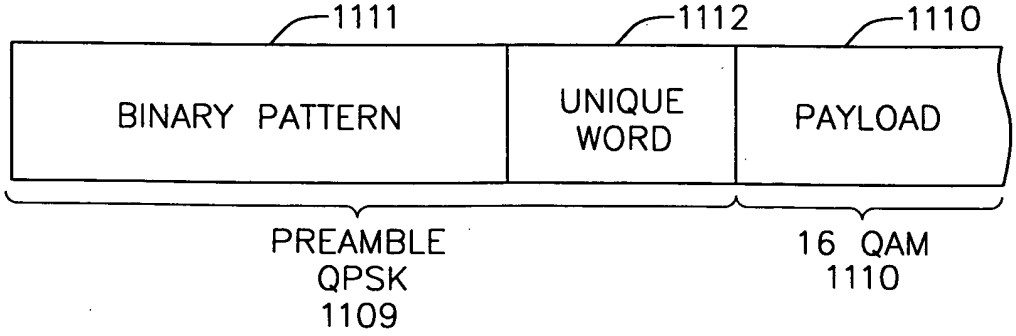


FIG. 18

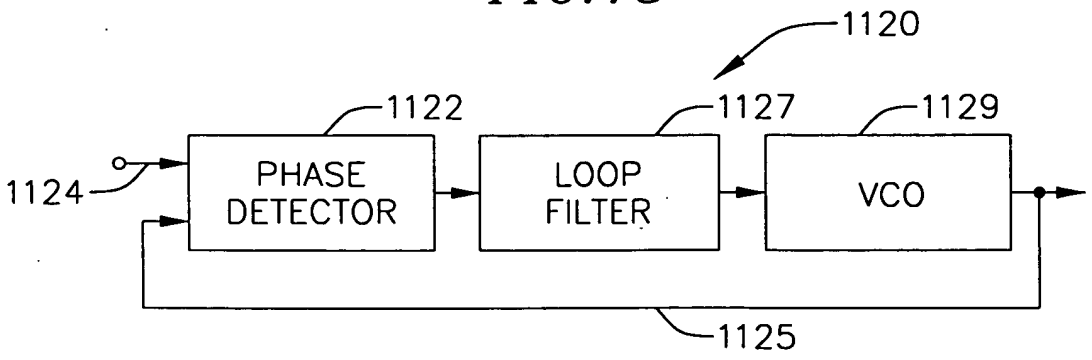


FIG. 19

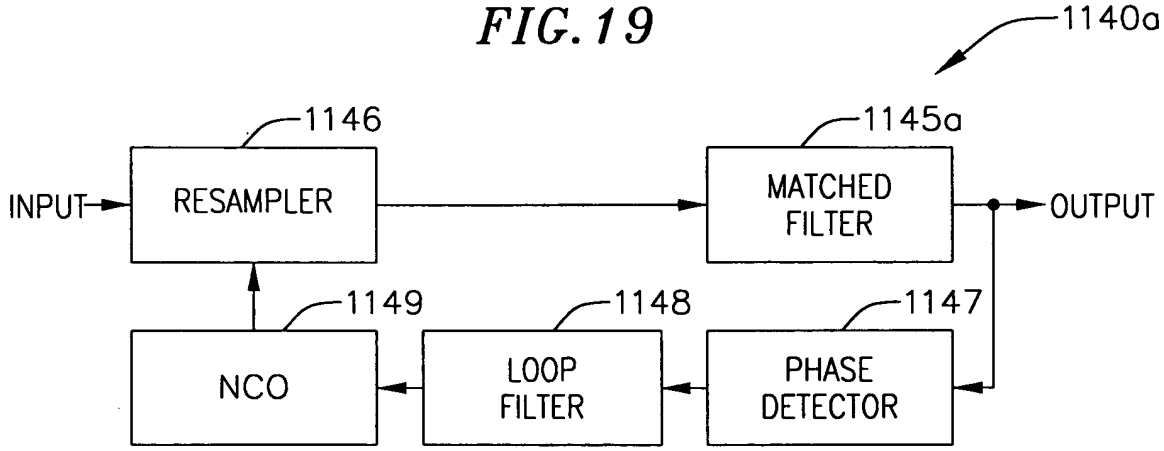


FIG. 20

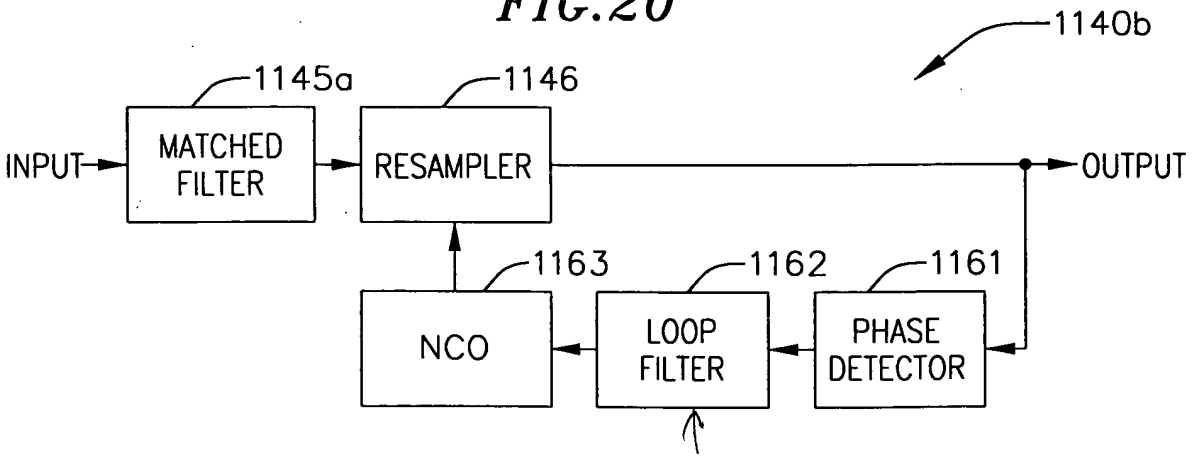


FIG.21

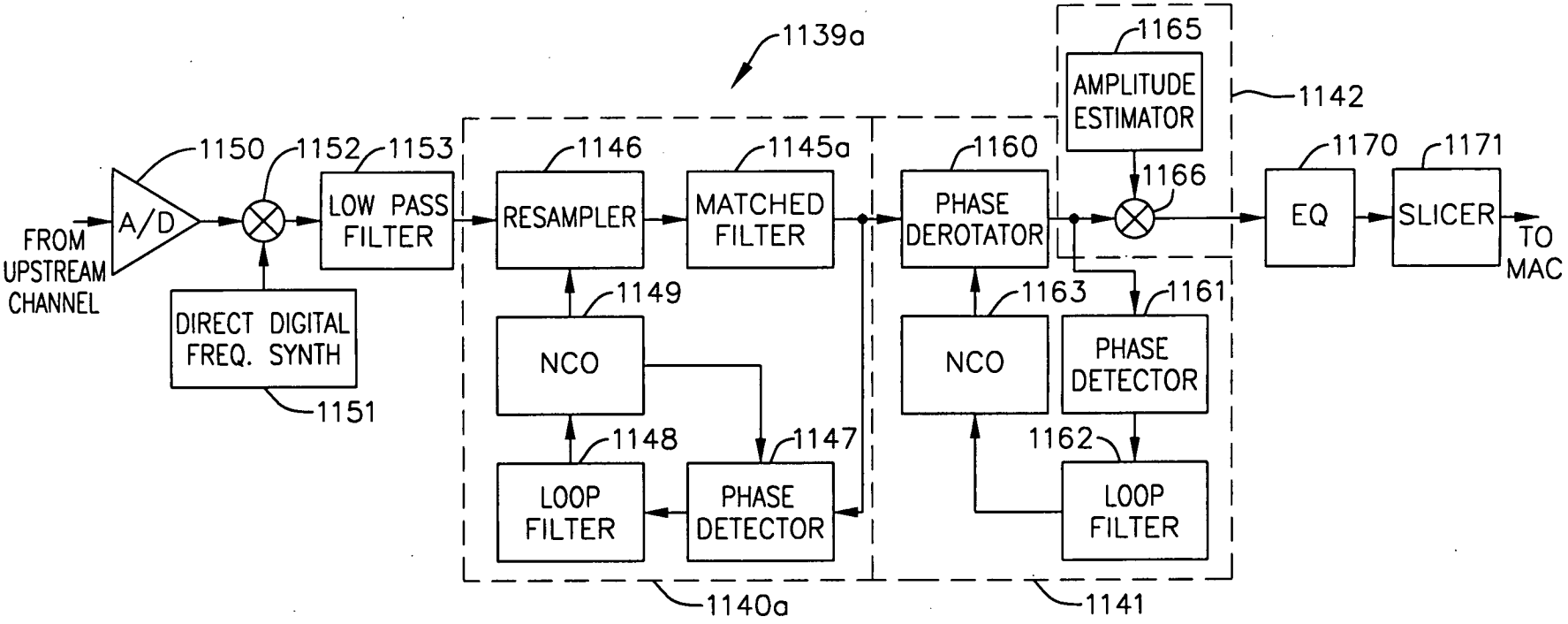

1139a
1165
AMPLITUDE ESTIMATOR
1142
1150
1152
1153
1146
1145a
1160
1166
1170
1171
FROM UPSTREAM CHANNEL
A/D
LOW PASS FILTER
RESAMPLER
MATCHED FILTER
PHASE DEROTATOR
EQ
SLICER
TO MAC
1149
1163
1161
DIRECT DIGITAL FREQ. SYNTH
NCO
NCO
PHASE DETECTOR
1151
1148
1147
1162
LOOP FILTER
PHASE DETECTOR
LOOP FILTER
1140a
1141

FIG.22

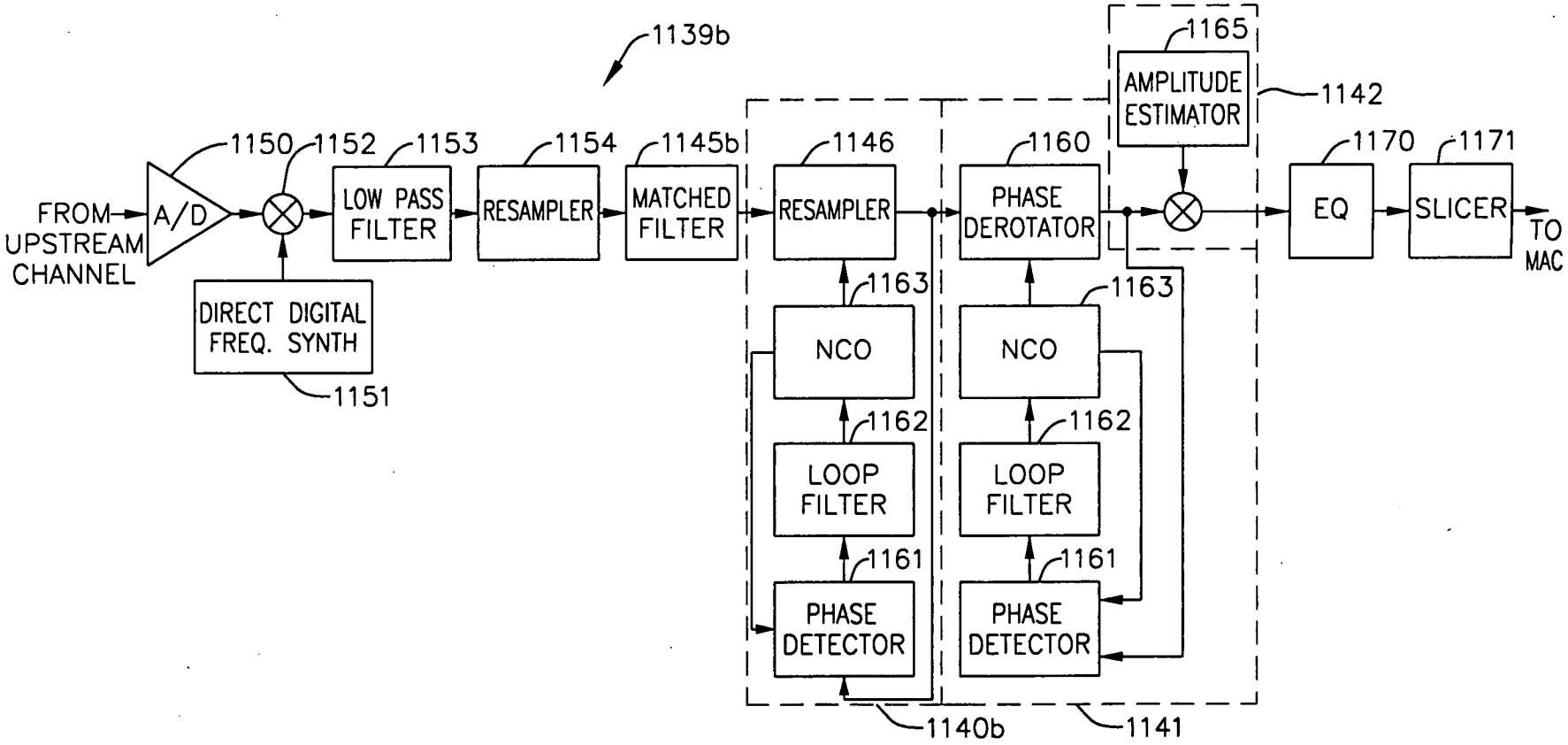

1139b
1165
AMPLITUDE ESTIMATOR
1142
1150
1152
1153
1154
1145b
1146
1160
1170
1171
FROM UPSTREAM CHANNEL
A/D
LOW PASS FILTER
RESAMPLER
MATCHED FILTER
RESAMPLER
PHASE DEROTATOR
EQ
SLICER
TO MAC
1163
1163
NCO
NCO
1162
1162
LOOP FILTER
LOOP FILTER
1161
1161
PHASE DETECTOR
PHASE DETECTOR
DIRECT DIGITAL FREQ. SYNTH
1151
1140b
1141

FIG.23

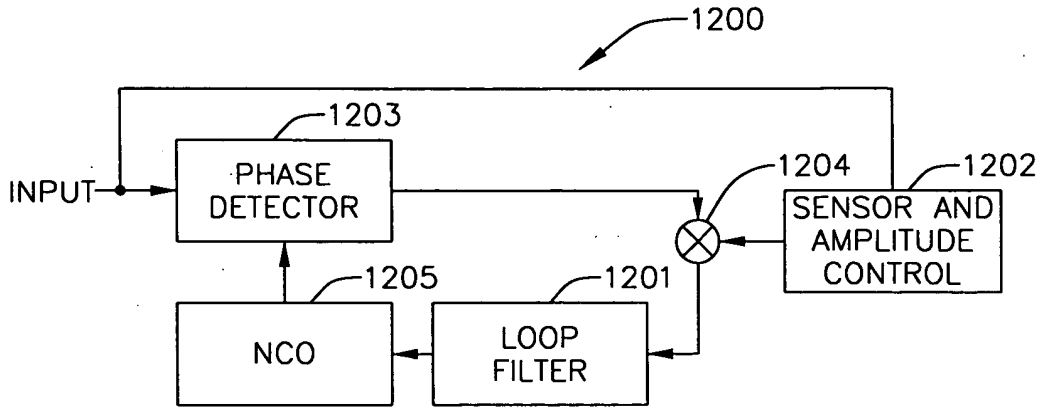

1200
1203
INPUT
PHASE DETECTOR
1204
1202
SENSOR AND AMPLITUDE CONTROL
1205
1201
NCO
LOOP FILTER

FIG.24

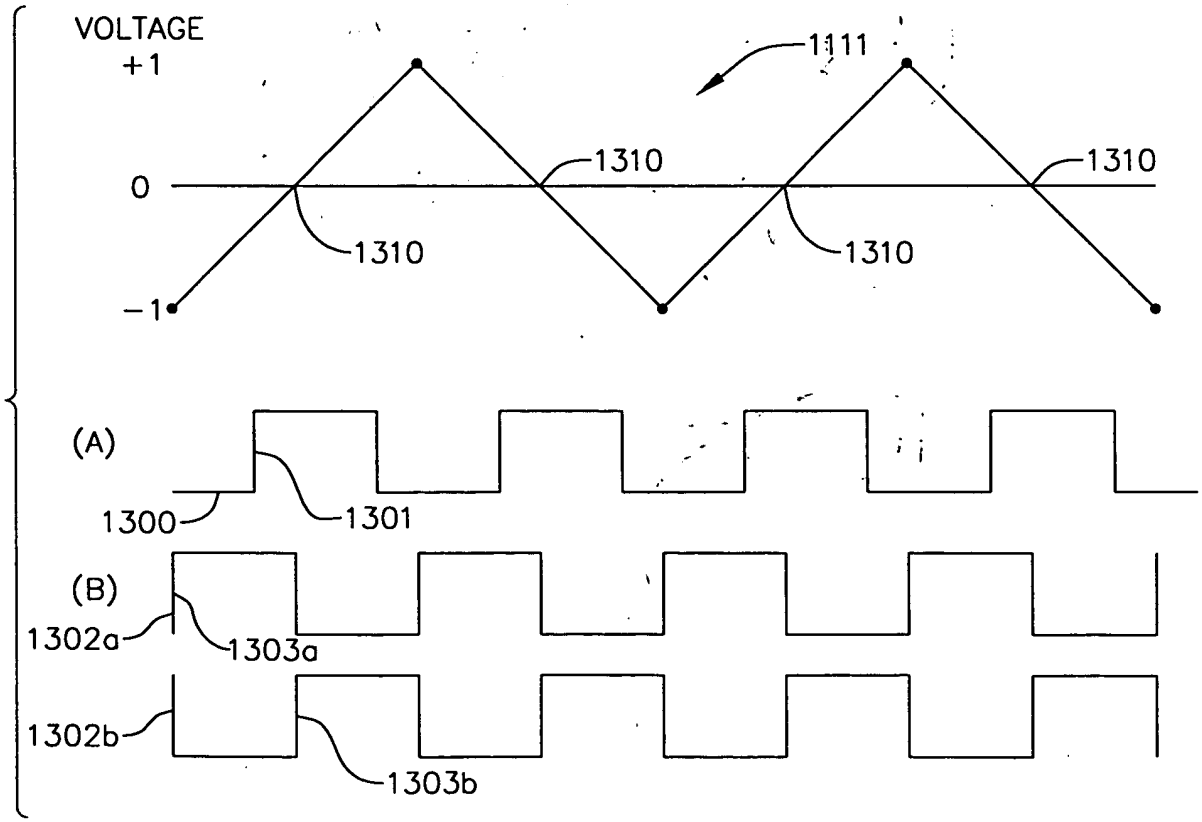

VOLTAGE
+1
0
−1
1111
1310
1310
1310
1310
(A)
1300
1301
(B)
1302a
1303a
1302b
1303b

FIG.25A

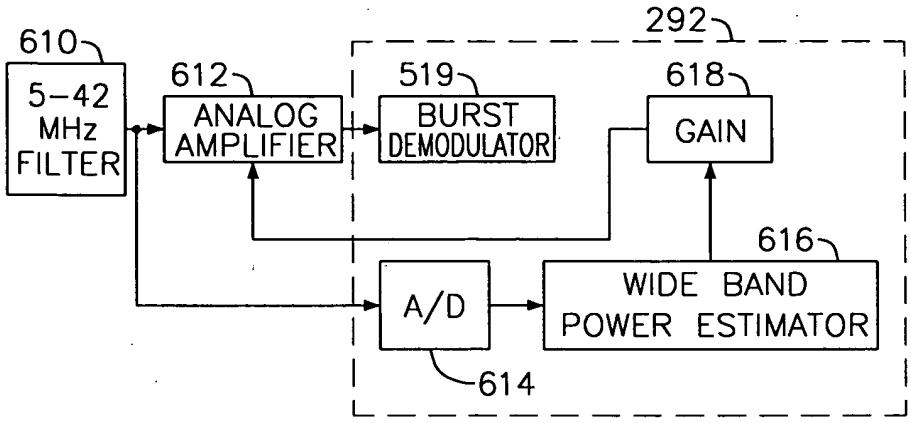
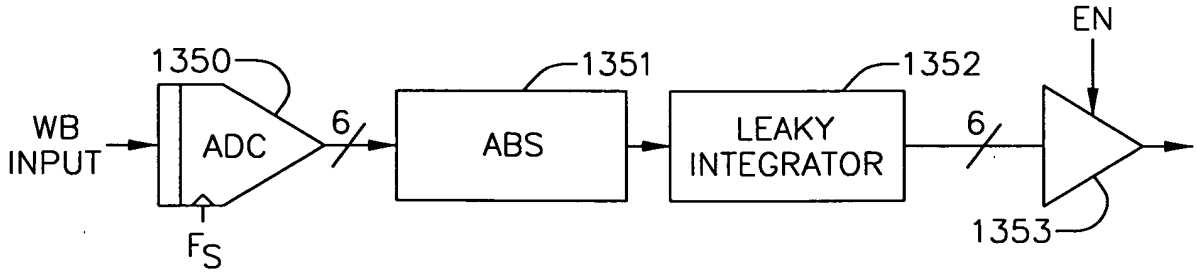


FIG.25B



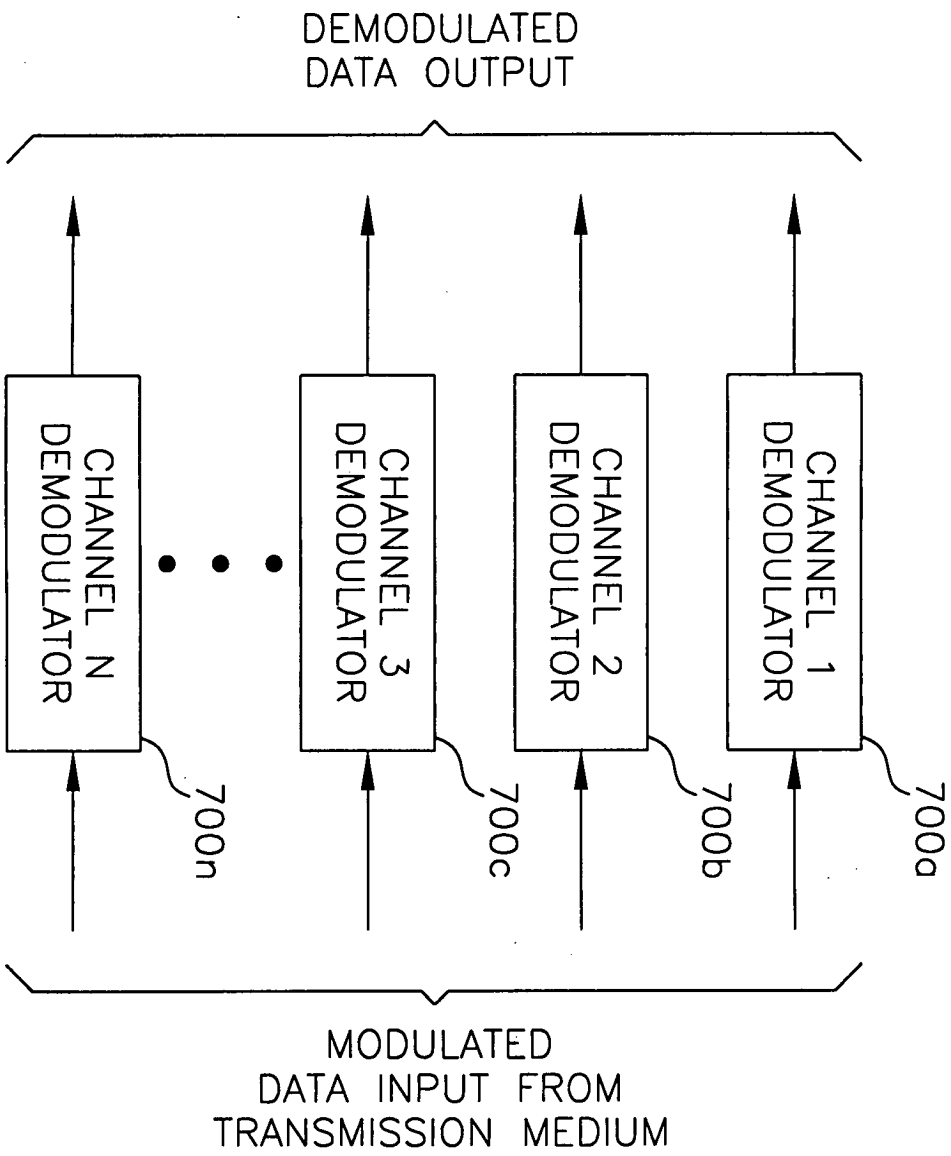

DEMODULATED
DATA OUTPUT
CHANNEL 1
DEMODULATOR
CHANNEL 2
DEMODULATOR
CHANNEL 3
DEMODULATOR
CHANNEL N
DEMODULATOR
700a
700b
700c
700n
MODULATED
DATA INPUT FROM
TRANSMISSION MEDIUM

FIG.26

FIG.27

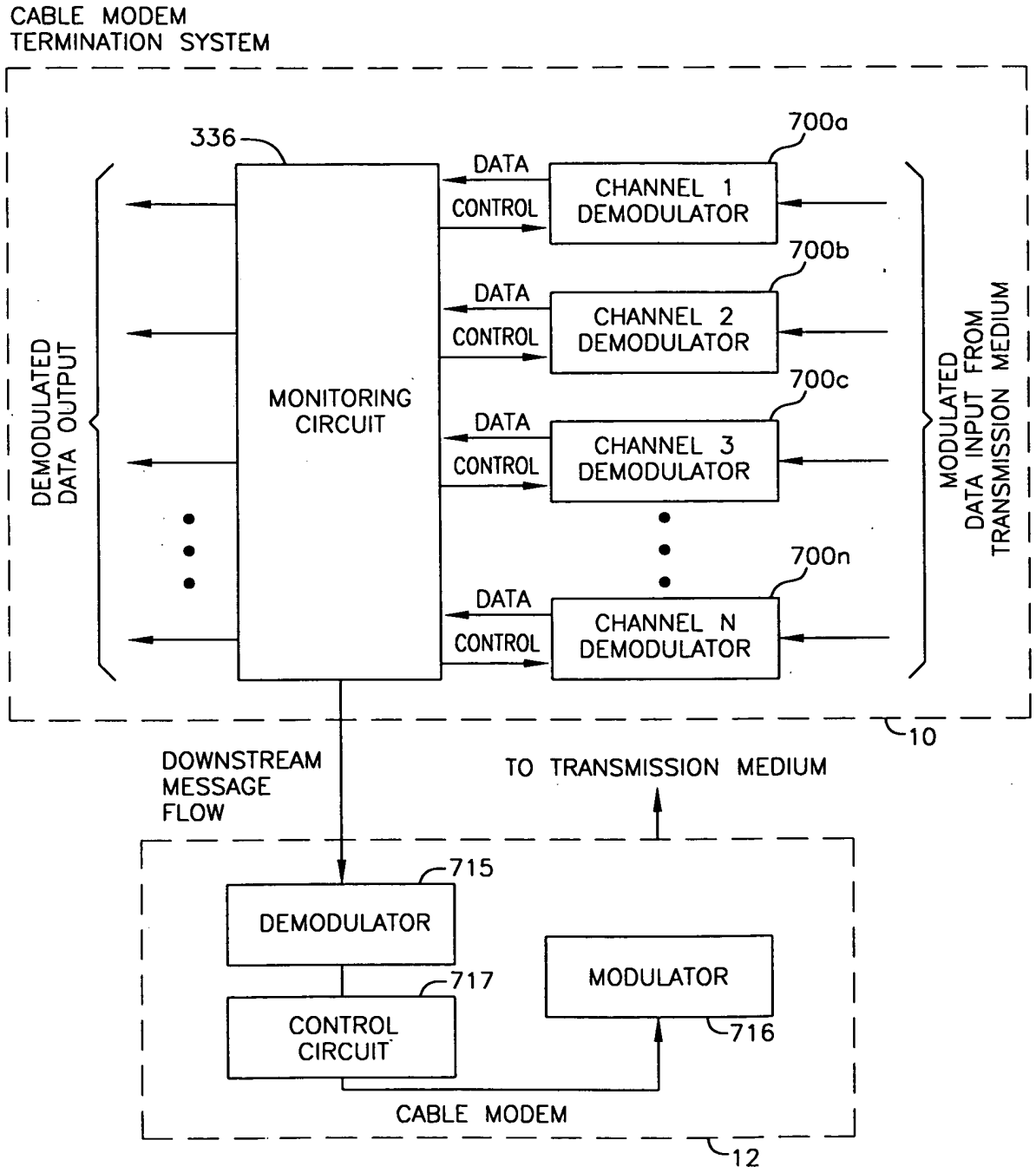

CABLE MODEM
TERMINATION SYSTEM
336
700a
700b
700c
700n
DATA
CONTROL
CHANNEL 1
DEMODULATOR
CHANNEL 2
DEMODULATOR
CHANNEL 3
DEMODULATOR
CHANNEL N
DEMODULATOR
MONITORING
CIRCUIT
DEMODULATED
DATA OUTPUT
MODULATED
DATA INPUT FROM
TRANSMISSION MEDIUM
10
DOWNSTREAM
MESSAGE
FLOW
TO TRANSMISSION MEDIUM
715
DEMODULATOR
717
CONTROL
CIRCUIT
MODULATOR
716
CABLE MODEM
12

FIG.28

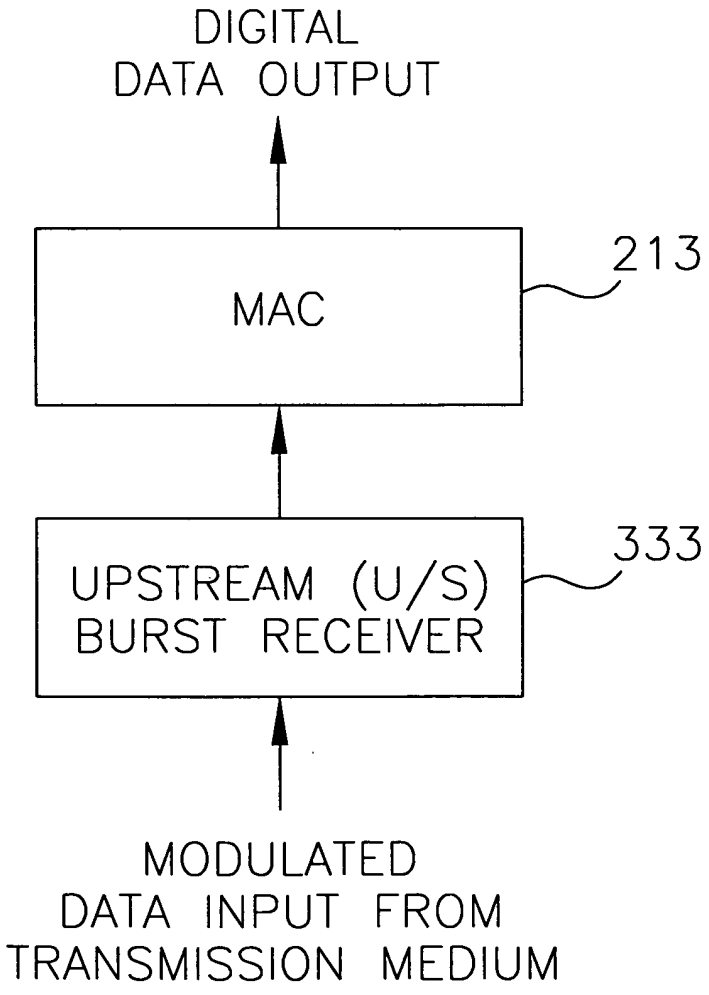

DIGITAL
DATA OUTPUT
MAC
213
UPSTREAM (U/S)
BURST RECEIVER
333
MODULATED
DATA INPUT FROM
TRANSMISSION MEDIUM

FIG.29

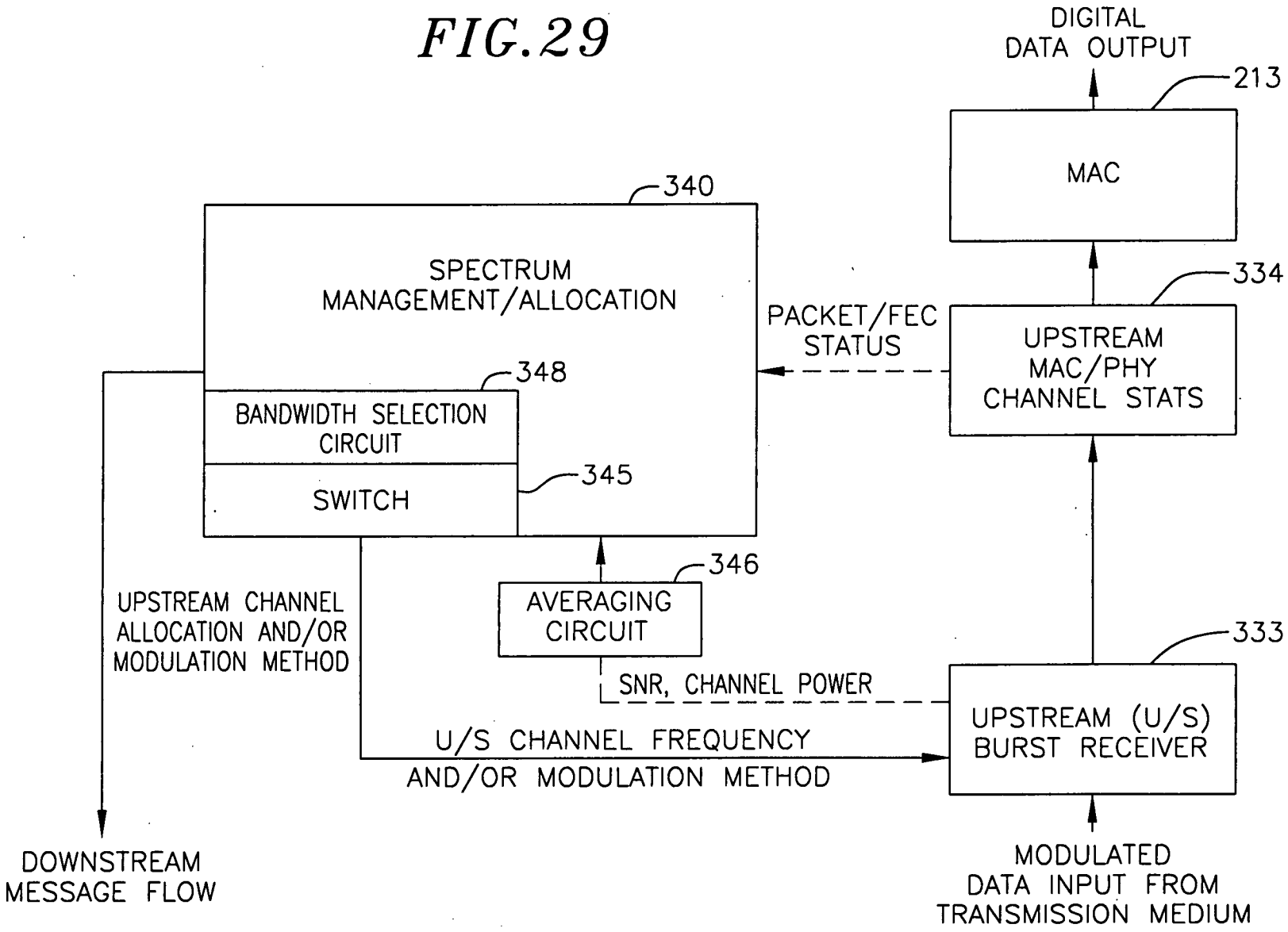

DIGITAL
DATA OUTPUT
213
MAC
340
SPECTRUM
MANAGEMENT/ALLOCATION
334
PACKET/FEC
STATUS
UPSTREAM
MAC/PHY
CHANNEL STATS
348
BANDWIDTH SELECTION
CIRCUIT
345
SWITCH
346
AVERAGING
CIRCUIT
UPSTREAM CHANNEL
ALLOCATION AND/OR
MODULATION METHOD
333
SNR, CHANNEL POWER
U/S CHANNEL FREQUENCY
AND/OR MODULATION METHOD
UPSTREAM (U/S)
BURST RECEIVER
DOWNSTREAM
MESSAGE FLOW
MODULATED
DATA INPUT FROM
TRANSMISSION MEDIUM

FIG.30

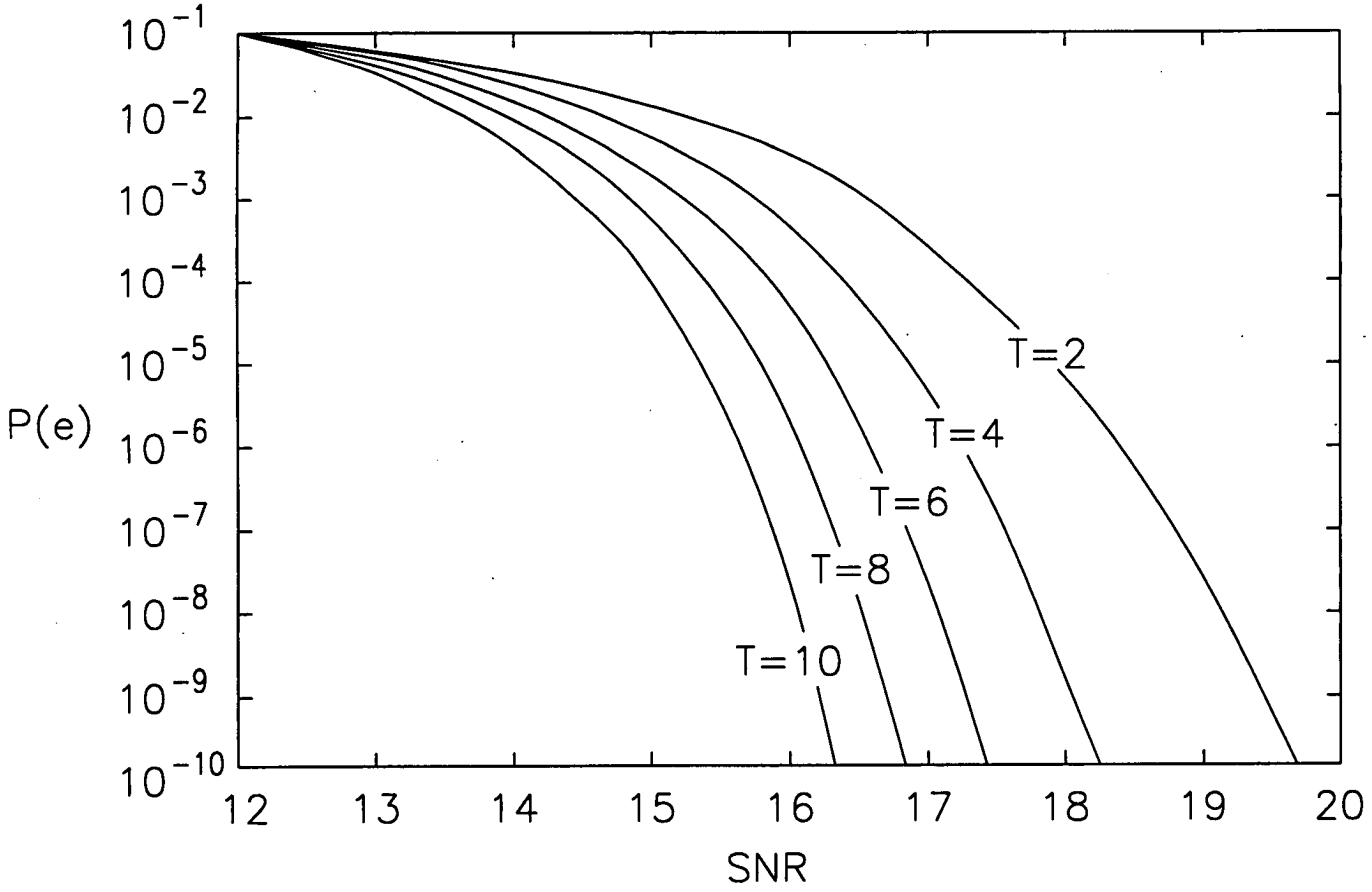

P(e)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
12
13
14
15
16
17
18
19
20
SNR
T=2
T=4
T=6
T=8
T=10

FIG.31

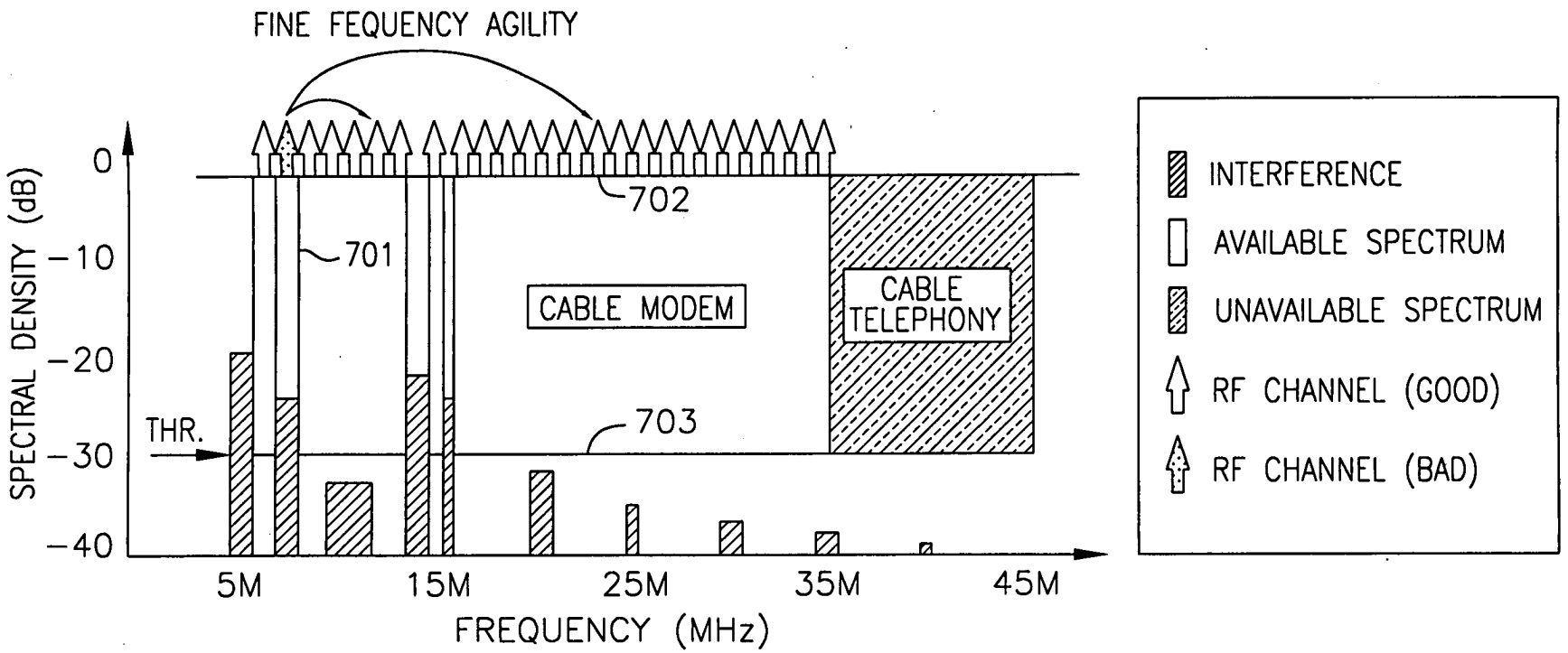

FINE FEQUENCY AGILITY
0
−10
−20
−30
−40
SPECTRAL DENSITY (dB)
THR.
701
702
703
CABLE MODEM
CABLE TELEPHONY
5M
15M
25M
35M
45M
FREQUENCY (MHz)
INTERFERENCE
AVAILABLE SPECTRUM
UNAVAILABLE SPECTRUM
RF CHANNEL (GOOD)
RF CHANNEL (BAD)

FIG.32

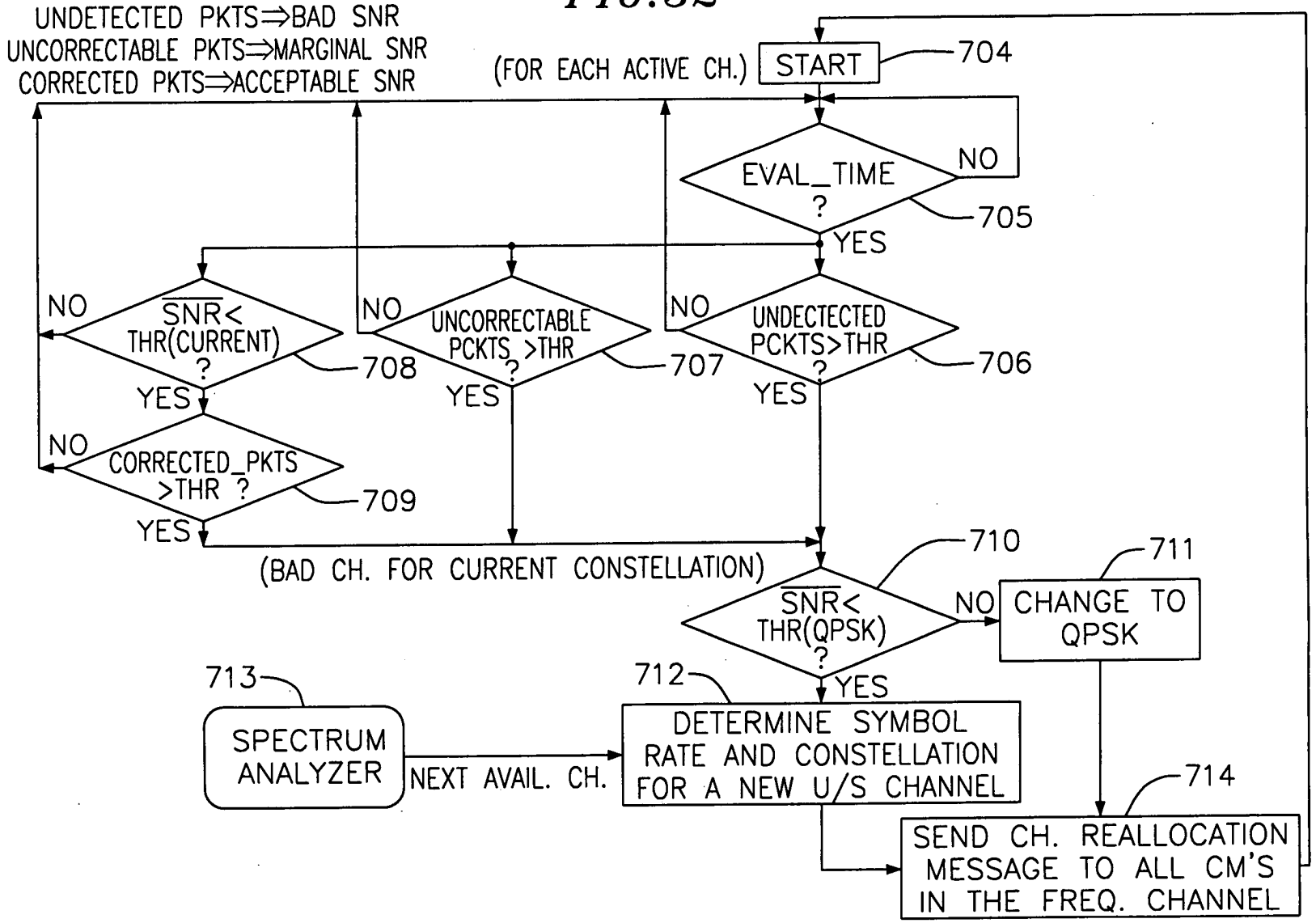

UNDETECTED PKTS⇒BAD SNR
UNCORRECTABLE PKTS⇒MARGINAL SNR
CORRECTED PKTS⇒ACCEPTABLE SNR
(FOR EACH ACTIVE CH.)
START
704
EVAL_TIME ?
NO
705
YES
SNR< THR(CURRENT) ?
NO
708
YES
UNCORRECTABLE PCKTS >THR ?
NO
707
YES
UNDETECTED PCKTS>THR ?
NO
706
YES
CORRECTED_PKTS >THR ?
NO
709
YES
(BAD CH. FOR CURRENT CONSTELLATION)
710
SNR< THR(QPSK) ?
NO
711
CHANGE TO QPSK
YES
713
SPECTRUM ANALYZER
NEXT AVAIL. CH.
712
DETERMINE SYMBOL RATE AND CONSTELLATION FOR A NEW U/S CHANNEL
714
SEND CH. REALLOCATION MESSAGE TO ALL CM'S IN THE FREQ. CHANNEL

FIG.33

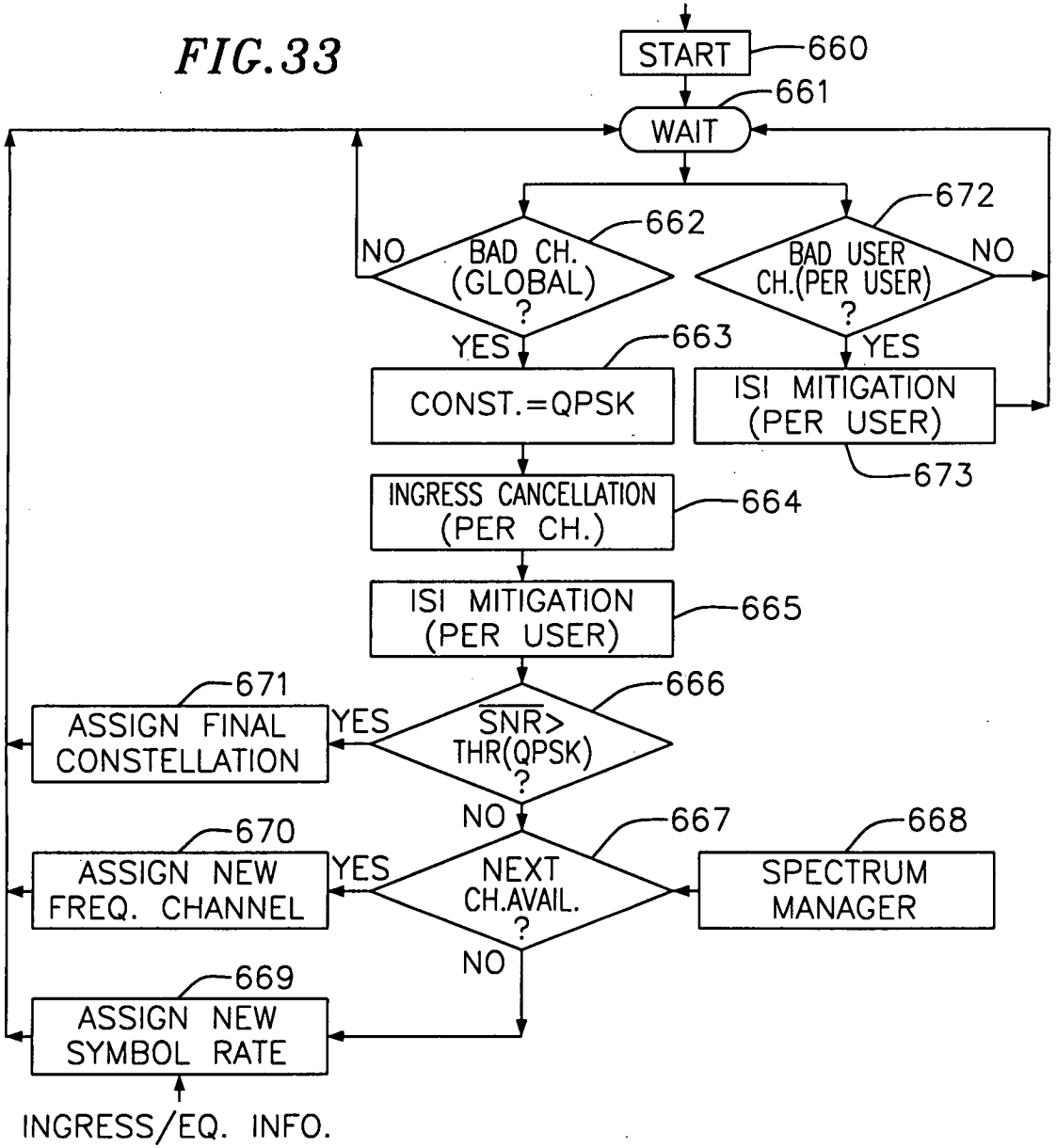

START
660
661
WAIT
672
662
NO
BAD CH. (GLOBAL) ?
BAD USER CH.(PER USER) ?
NO
YES
YES
663
CONST.=QPSK
ISI MITIGATION (PER USER)
673
INGRESS CANCELLATION (PER CH.)
664
ISI MITIGATION (PER USER)
665
671
666
ASSIGN FINAL CONSTELLATION
YES
SNR> THR(QPSK) ?
NO
670
667
668
ASSIGN NEW FREQ. CHANNEL
YES
NEXT CH.AVAIL. ?
SPECTRUM MANAGER
NO
669
ASSIGN NEW SYMBOL RATE
INGRESS/EQ. INFO.

FIG.34

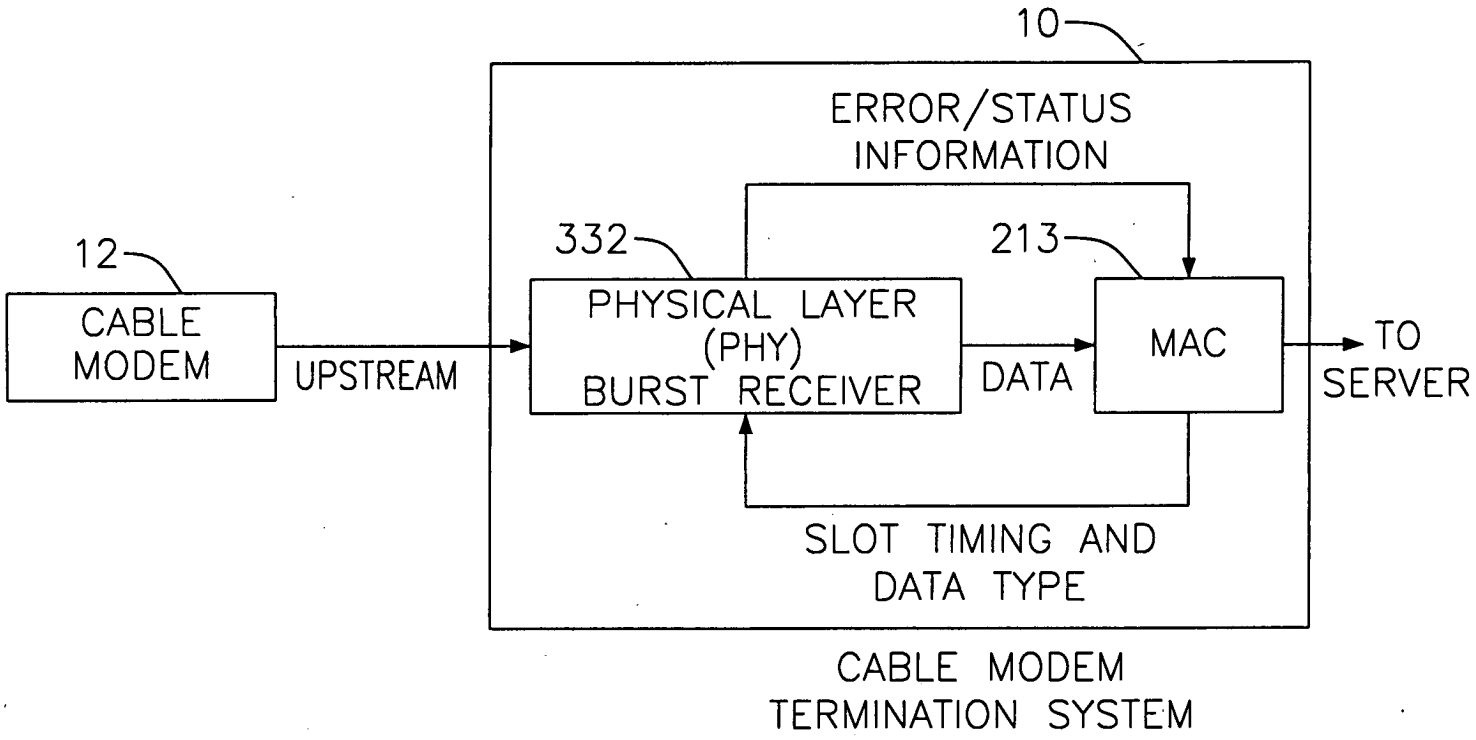

10
ERROR/STATUS
INFORMATION
12
CABLE
MODEM
UPSTREAM
332
PHYSICAL LAYER
(PHY)
BURST RECEIVER
213
DATA
MAC
TO
SERVER
SLOT TIMING AND
DATA TYPE
CABLE MODEM
TERMINATION SYSTEM

FIG.35

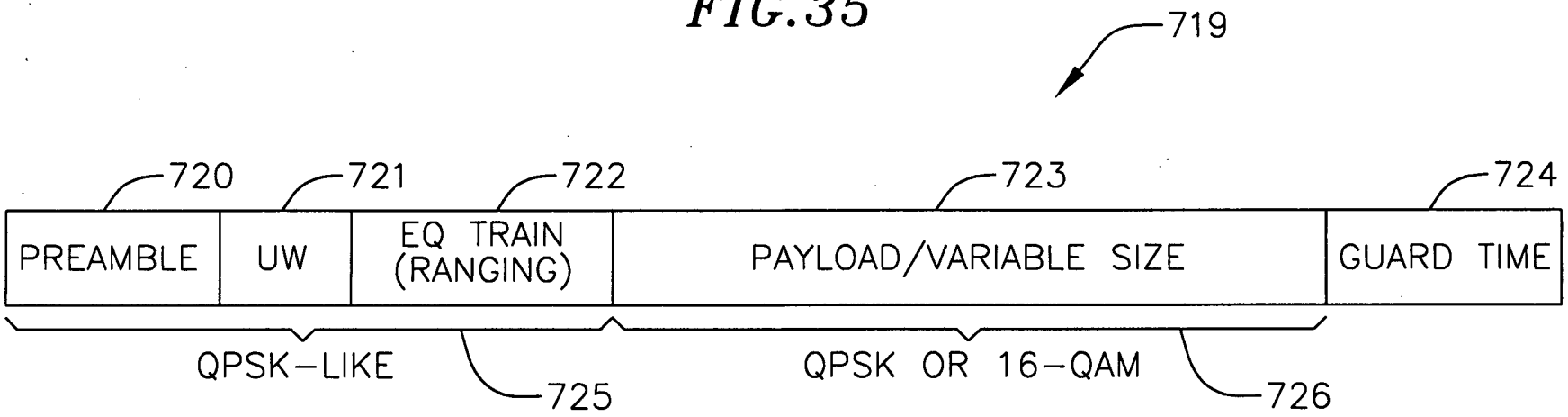

719
720
721
722
723
724
PREAMBLE
UW
EQ TRAIN (RANGING)
PAYLOAD/VARIABLE SIZE
GUARD TIME
QPSK-LIKE
QPSK OR 16-QAM
725
726

FIG.36

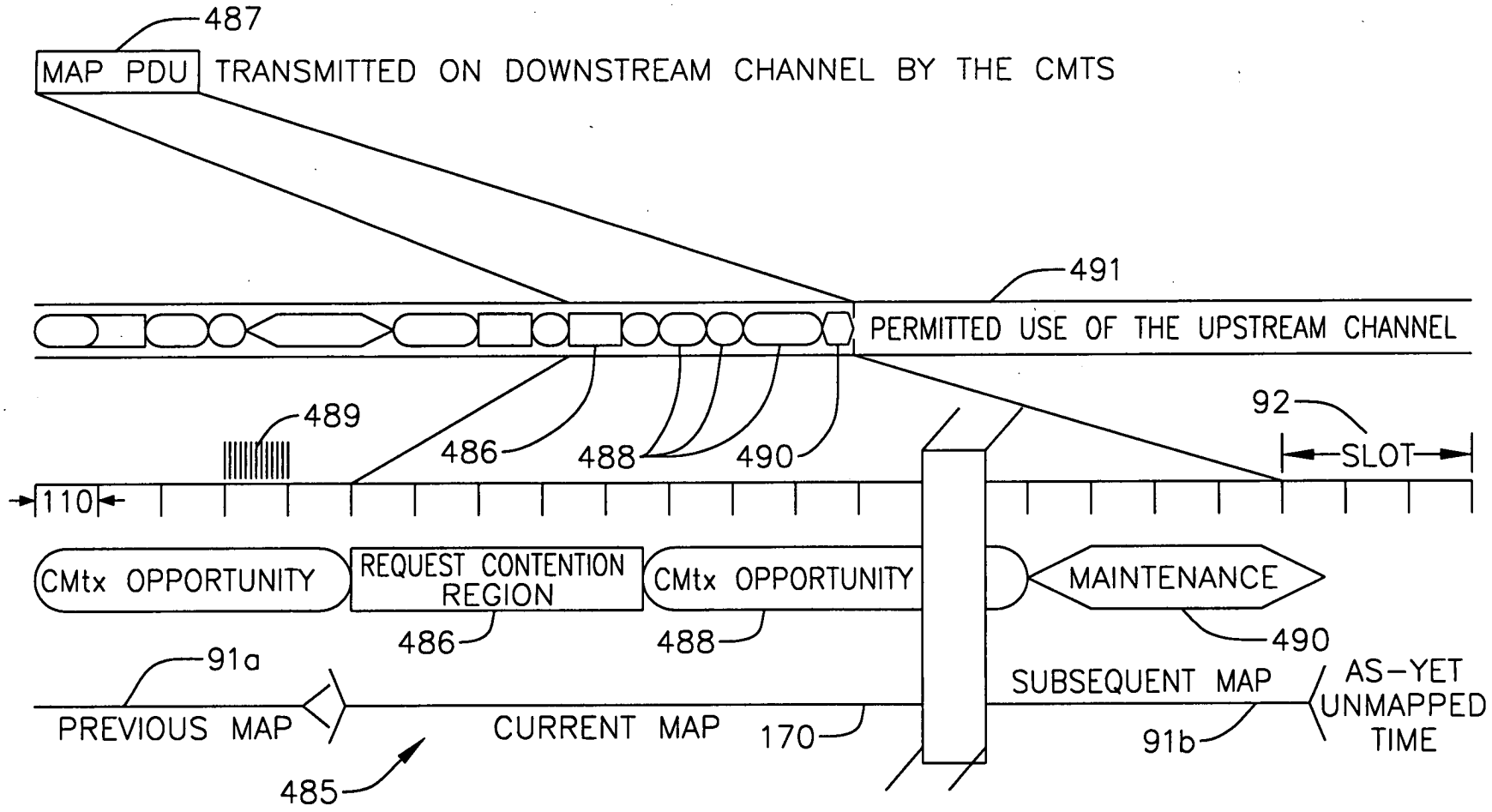

487
MAP PDU
TRANSMITTED ON DOWNSTREAM CHANNEL BY THE CMTS
491
PERMITTED USE OF THE UPSTREAM CHANNEL
489
486
488
490
92
SLOT
110
CMtx OPPORTUNITY
REQUEST CONTENTION REGION
CMtx OPPORTUNITY
MAINTENANCE
486
488
490
91a
PREVIOUS MAP
CURRENT MAP
170
SUBSEQUENT MAP
AS-YET UNMAPPED TIME
91b
485

FIG.37

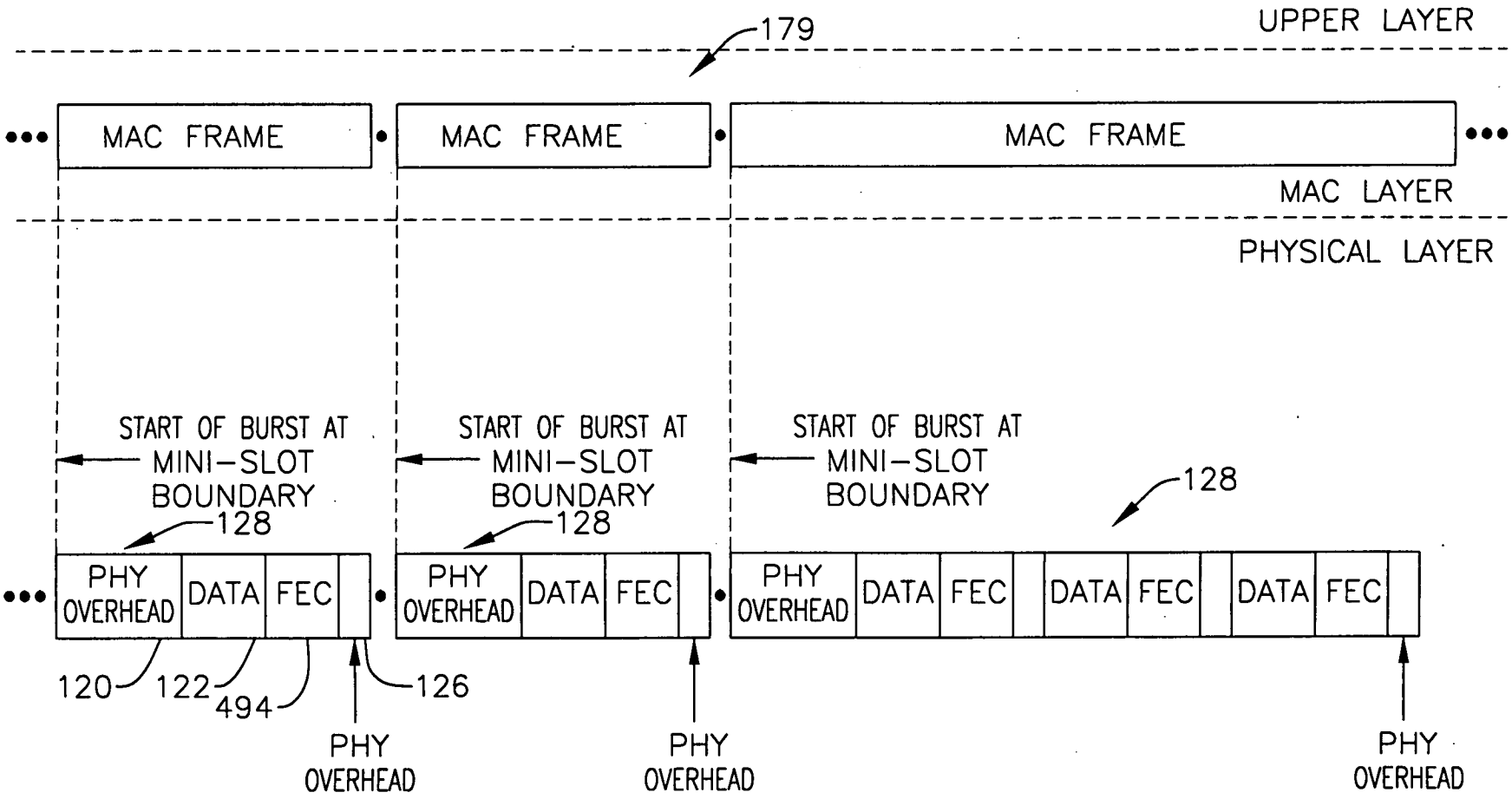
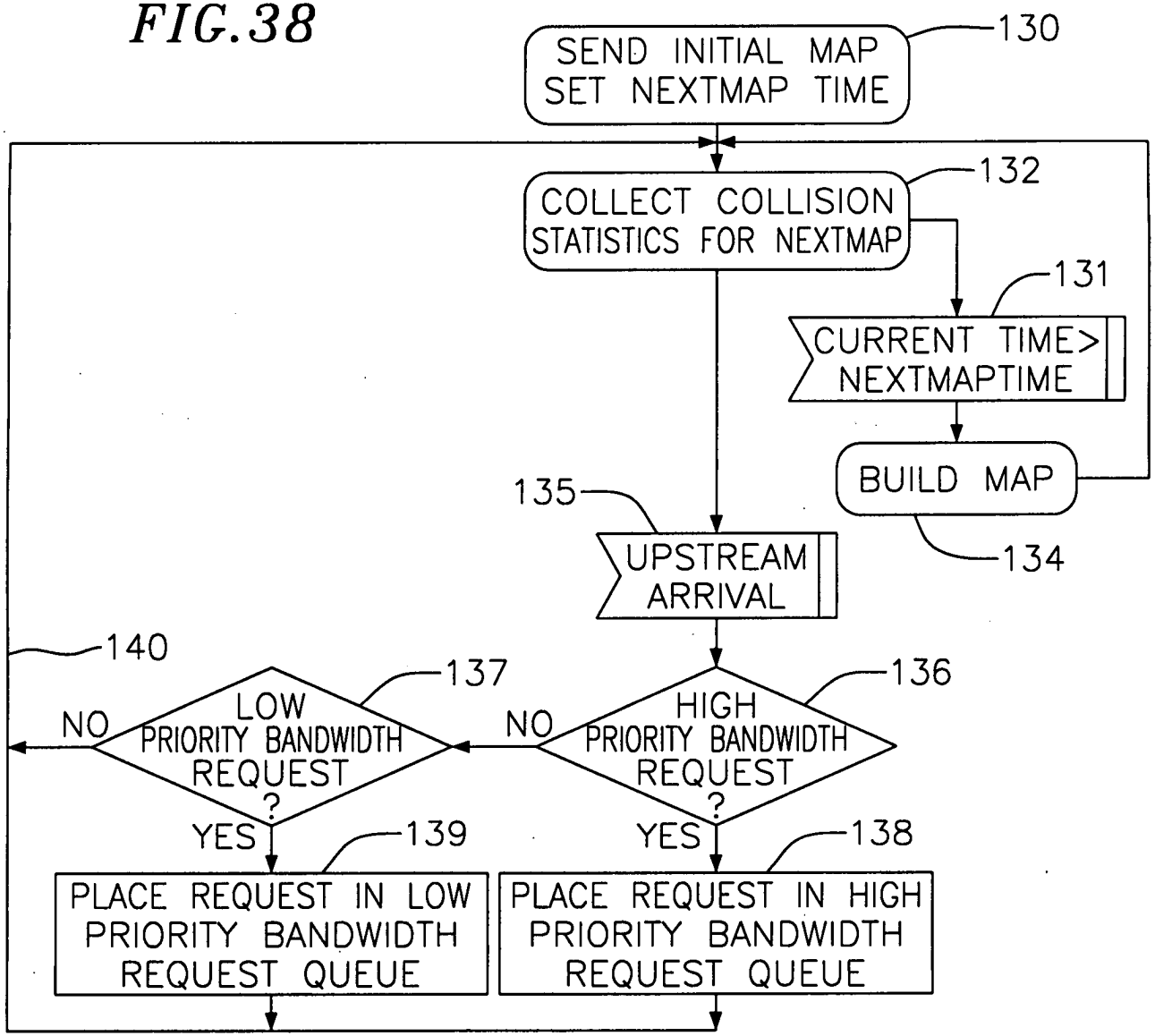

UPPER LAYER
179
MAC FRAME
MAC FRAME
MAC FRAME
MAC LAYER
PHYSICAL LAYER
START OF BURST AT MINI-SLOT BOUNDARY
128
START OF BURST AT MINI-SLOT BOUNDARY
128
START OF BURST AT MINI-SLOT BOUNDARY
128
PHY OVERHEAD
DATA
FEC
PHY OVERHEAD
DATA
FEC
PHY OVERHEAD
DATA
FEC
DATA
FEC
DATA
FEC
120
122
494
126
PHY OVERHEAD
PHY OVERHEAD
PHY OVERHEAD

FIG.38


SEND INITIAL MAP
SET NEXTMAP TIME
130
COLLECT COLLISION
STATISTICS FOR NEXTMAP
132
131
CURRENT TIME>
NEXTMAPTIME
BUILD MAP
134
135
UPSTREAM
ARRIVAL
140
137
136
NO
LOW
PRIORITY BANDWIDTH
REQUEST
?
NO
HIGH
PRIORITY BANDWIDTH
REQUEST
?
YES
YES
139
138
PLACE REQUEST IN LOW
PRIORITY BANDWIDTH
REQUEST QUEUE
PLACE REQUEST IN HIGH
PRIORITY BANDWIDTH
REQUEST QUEUE

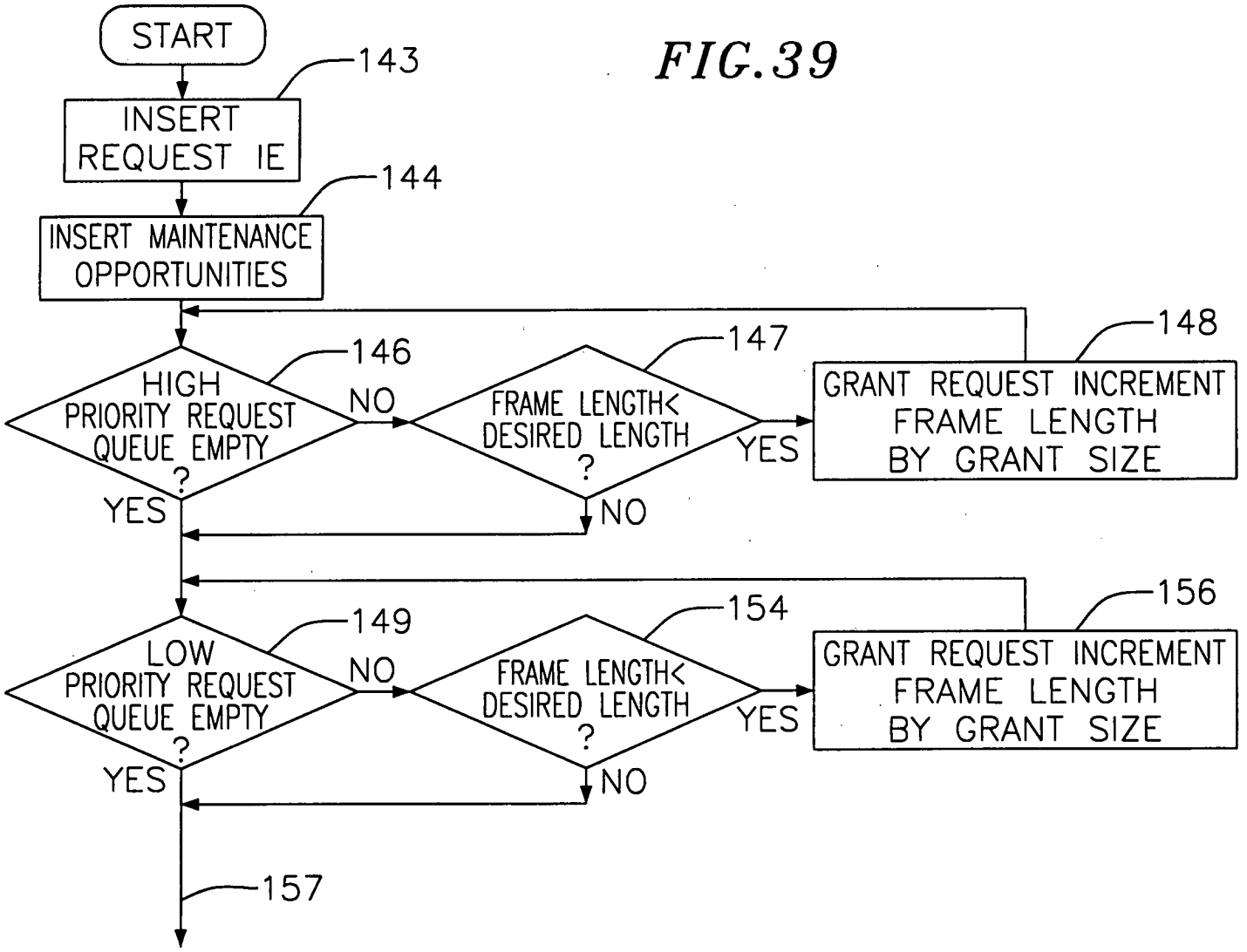

START
143
INSERT REQUEST IE
144
INSERT MAINTENANCE OPPORTUNITIES
146
HIGH PRIORITY REQUEST QUEUE EMPTY ?
NO
147
FRAME LENGTH< DESIRED LENGTH ?
YES
148
GRANT REQUEST INCREMENT FRAME LENGTH BY GRANT SIZE
YES
NO
149
LOW PRIORITY REQUEST QUEUE EMPTY ?
NO
154
FRAME LENGTH< DESIRED LENGTH ?
YES
156
GRANT REQUEST INCREMENT FRAME LENGTH BY GRANT SIZE
YES
NO
157

FIG.39

FIG.40

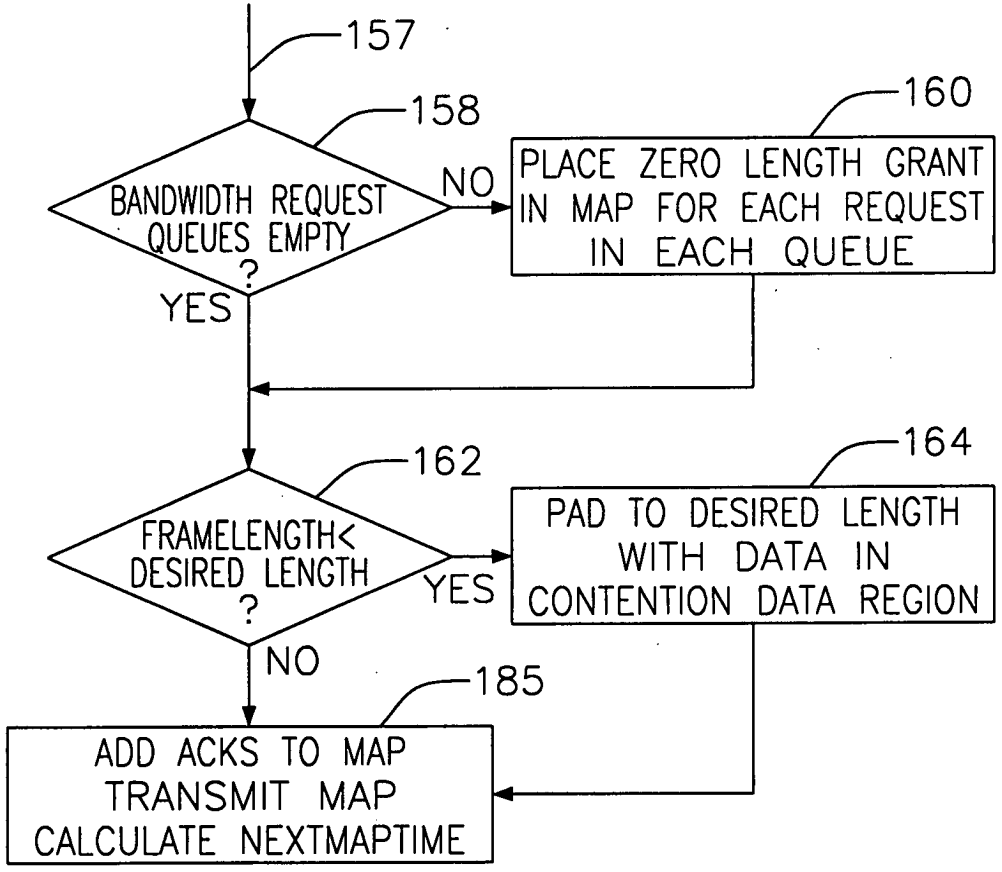

157
158
BANDWIDTH REQUEST QUEUES EMPTY ?
NO
YES
160
PLACE ZERO LENGTH GRANT IN MAP FOR EACH REQUEST IN EACH QUEUE
162
FRAMELENGTH< DESIRED LENGTH ?
YES
NO
164
PAD TO DESIRED LENGTH WITH DATA IN CONTENTION DATA REGION
185
ADD ACKS TO MAP
TRANSMIT MAP
CALCULATE NEXTMAPTIME

FIG. 41

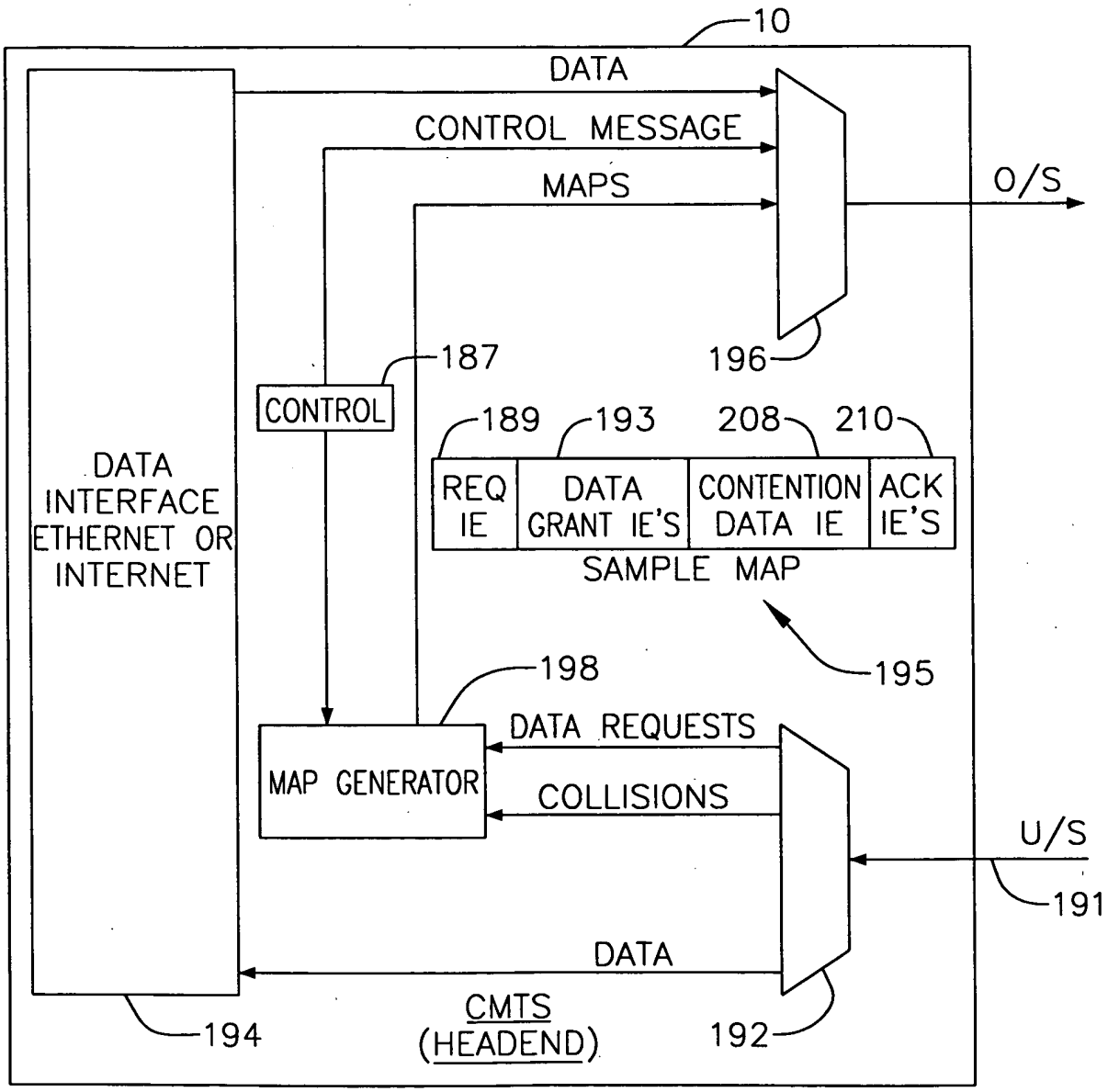

10
DATA
CONTROL MESSAGE
MAPS
O/S
196
187
CONTROL
189
193
208
210
REQ IE
DATA GRANT IE'S
CONTENTION DATA IE
ACK IE'S
SAMPLE MAP
195
DATA INTERFACE ETHERNET OR INTERNET
198
DATA REQUESTS
MAP GENERATOR
COLLISIONS
U/S
191
DATA
CMTS (HEADEND)
194
192

FIG. 42

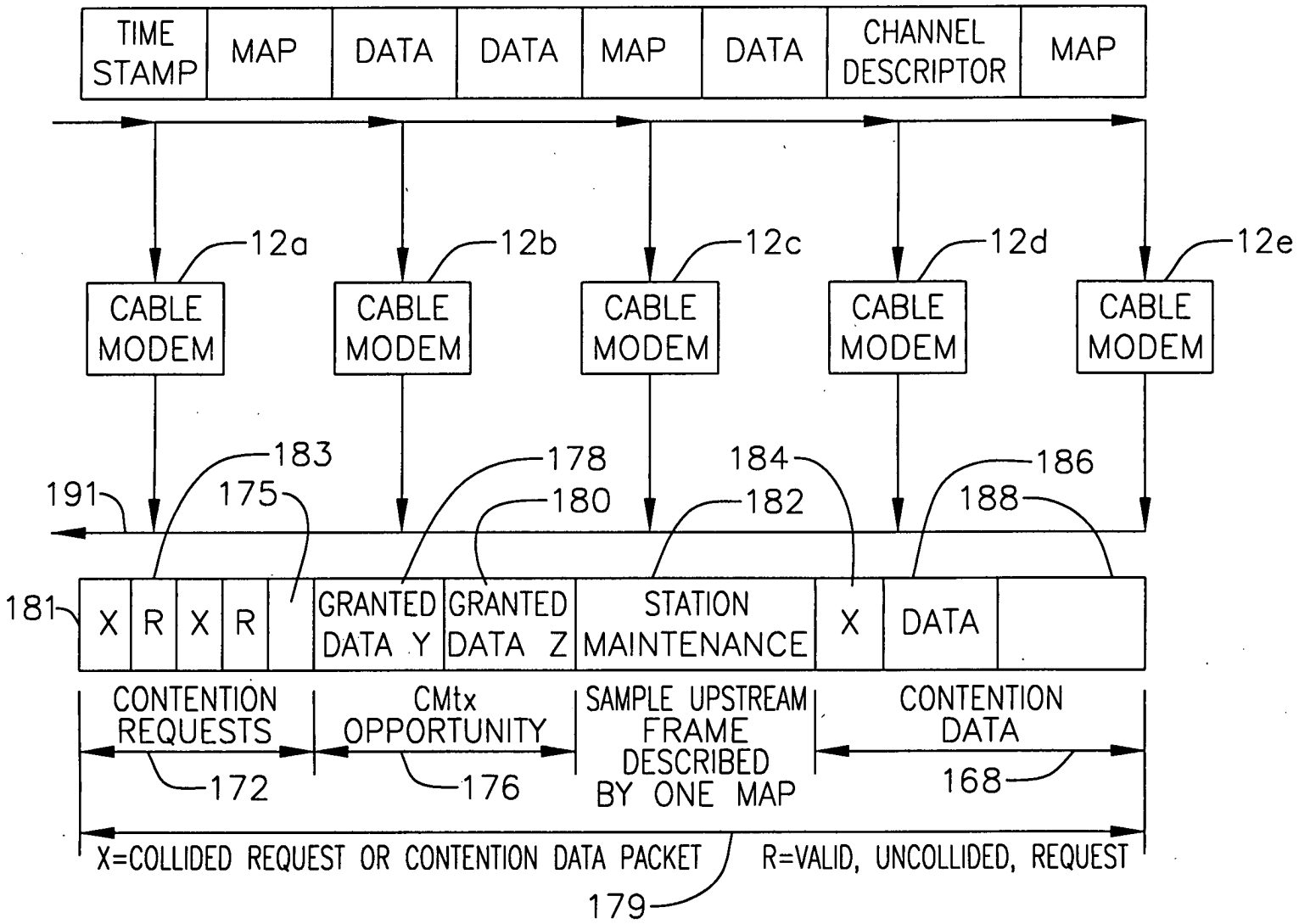

TIME STAMP
MAP
DATA
DATA
MAP
DATA
CHANNEL DESCRIPTOR
MAP
12a
12b
12c
12d
12e
CABLE MODEM
CABLE MODEM
CABLE MODEM
CABLE MODEM
CABLE MODEM
191
183
175
178
180
184
182
186
188
181
X
R
X
R
GRANTED DATA Y
GRANTED DATA Z
STATION MAINTENANCE
X
DATA
CONTENTION REQUESTS
CMtx OPPORTUNITY
SAMPLE UPSTREAM FRAME DESCRIBED BY ONE MAP
CONTENTION DATA
172
176
168
X=COLLIDED REQUEST OR CONTENTION DATA PACKET
R=VALID, UNCOLLIDED, REQUEST
179

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FIG. 43

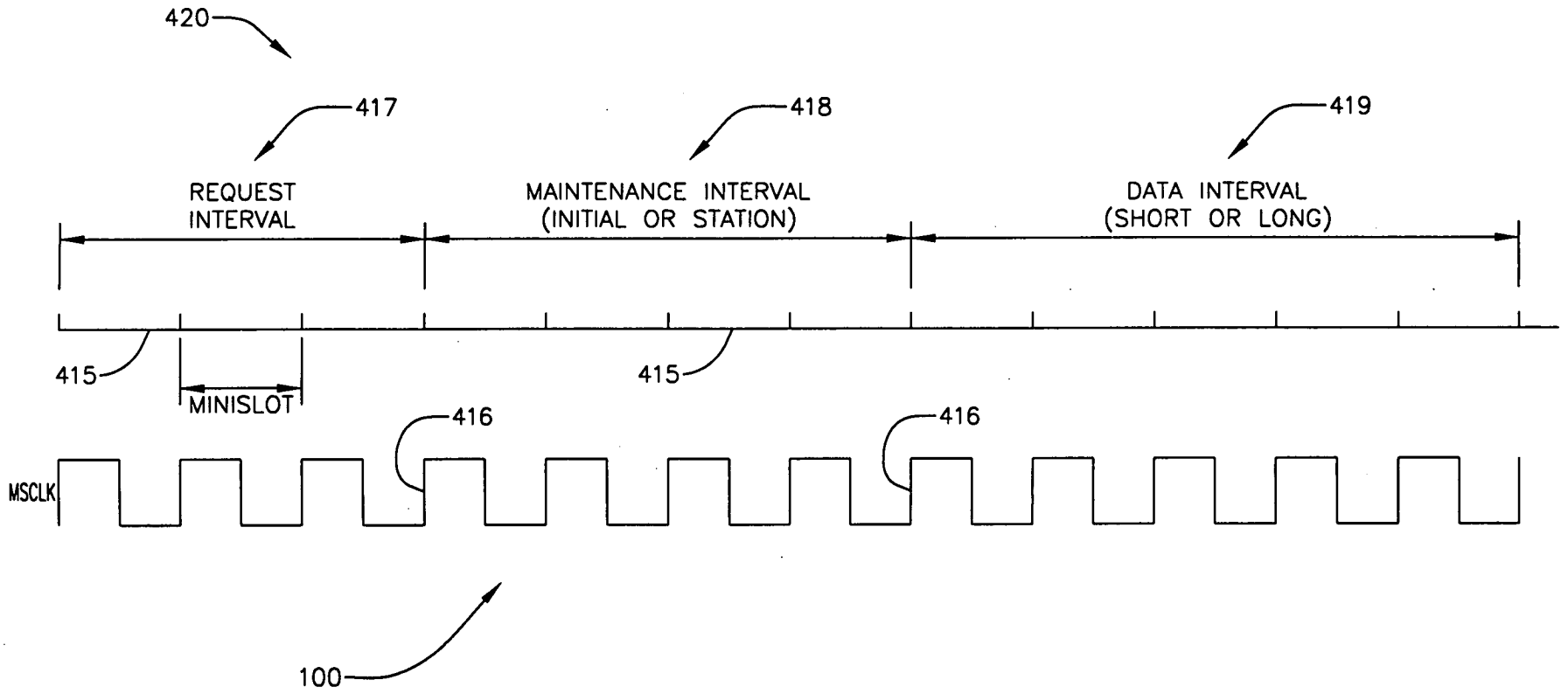

FIG.44

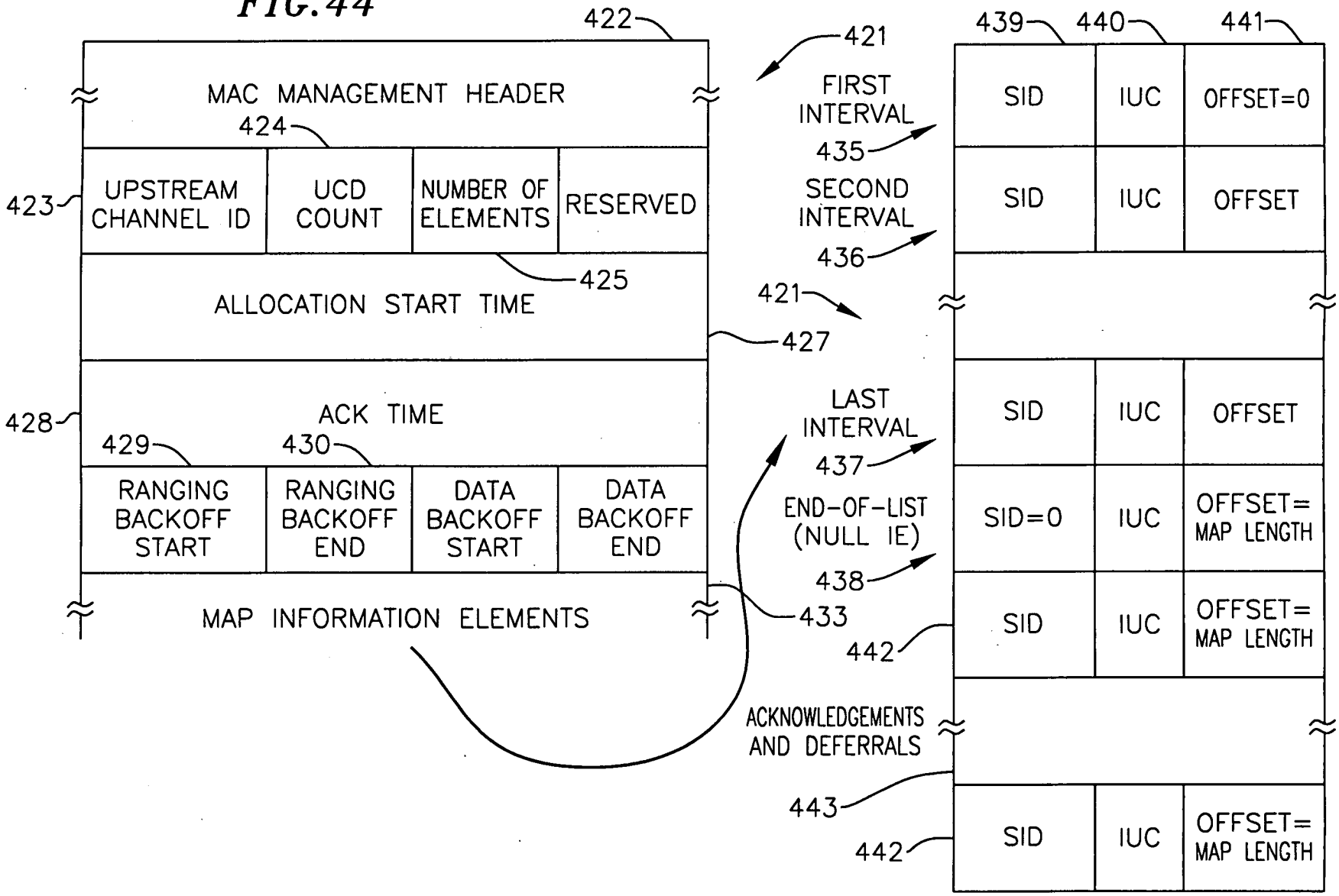
422
421
MAC MANAGEMENT HEADER
424
UPSTREAM CHANNEL ID
UCD COUNT
NUMBER OF ELEMENTS
RESERVED
423
425
ALLOCATION START TIME
427
428
ACK TIME
429
430
RANGING BACKOFF START
RANGING BACKOFF END
DATA BACKOFF START
DATA BACKOFF END
MAP INFORMATION ELEMENTS
433
439
440
441
FIRST INTERVAL
435
SECOND INTERVAL
436
LAST INTERVAL
437
END-OF-LIST (NULL IE)
438
ACKNOWLEDGEMENTS AND DEFERRALS
443
442
SID
IUC
OFFSET=0
OFFSET
SID=0
OFFSET= MAP LENGTH

FIG.45

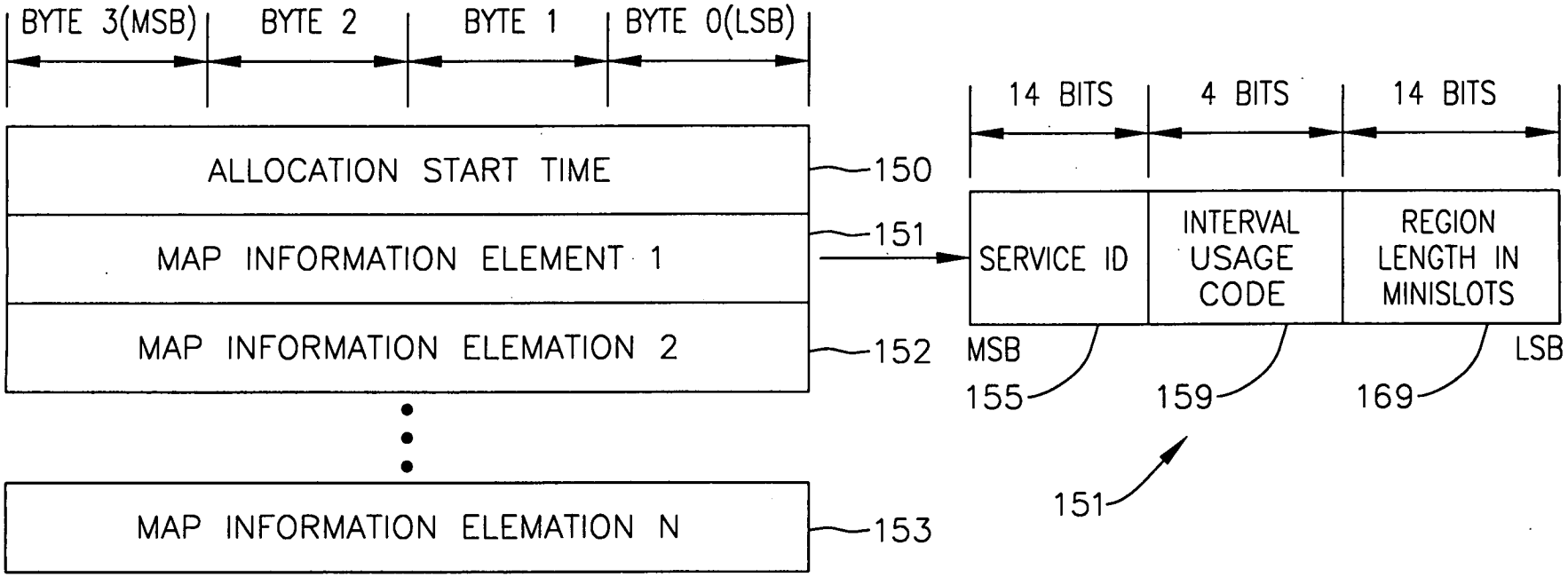
BYTE 3(MSB)
BYTE 2
BYTE 1
BYTE 0(LSB)
ALLOCATION START TIME
MAP INFORMATION ELEMENT 1
MAP INFORMATION ELEMATION 2
MAP INFORMATION ELEMATION N
150
151
152
153
14 BITS
4 BITS
14 BITS
SERVICE ID
INTERVAL USAGE CODE
REGION LENGTH IN MINISLOTS
MSB
LSB
155
159
169
151

FIG.46

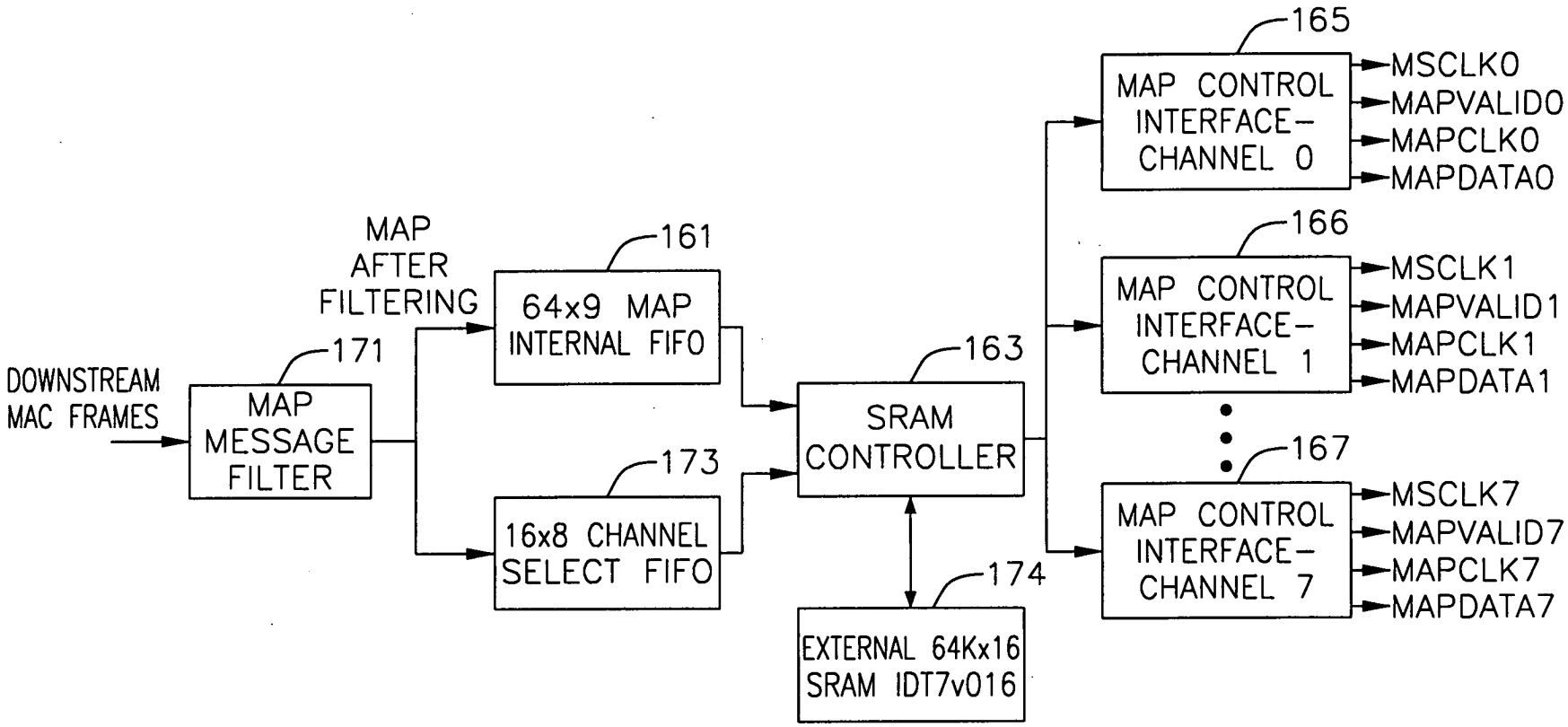
DOWNSTREAM MAC FRAMES
MAP MESSAGE FILTER
171
MAP AFTER FILTERING
64x9 MAP INTERNAL FIFO
161
16x8 CHANNEL SELECT FIFO
173
SRAM CONTROLLER
163
EXTERNAL 64Kx16 SRAM IDT7v016
174
MAP CONTROL INTERFACE- CHANNEL 0
165
MSCLK0
MAPVALID0
MAPCLK0
MAPDATA0
MAP CONTROL INTERFACE- CHANNEL 1
166
MSCLK1
MAPVALID1
MAPCLK1
MAPDATA1
MAP CONTROL INTERFACE- CHANNEL 7
167
MSCLK7
MAPVALID7
MAPCLK7
MAPDATA7

FIG.47

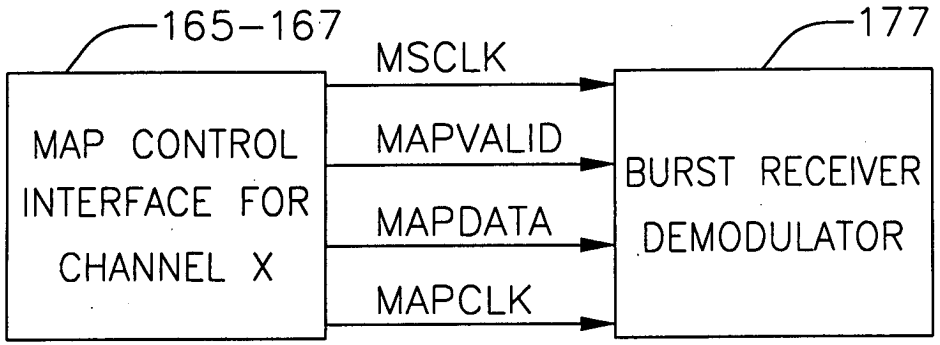
165–167
MSCLK
177
MAP CONTROL INTERFACE FOR CHANNEL X
MAPVALID
MAPDATA
MAPCLK
BURST RECEIVER DEMODULATOR

FIG. 48

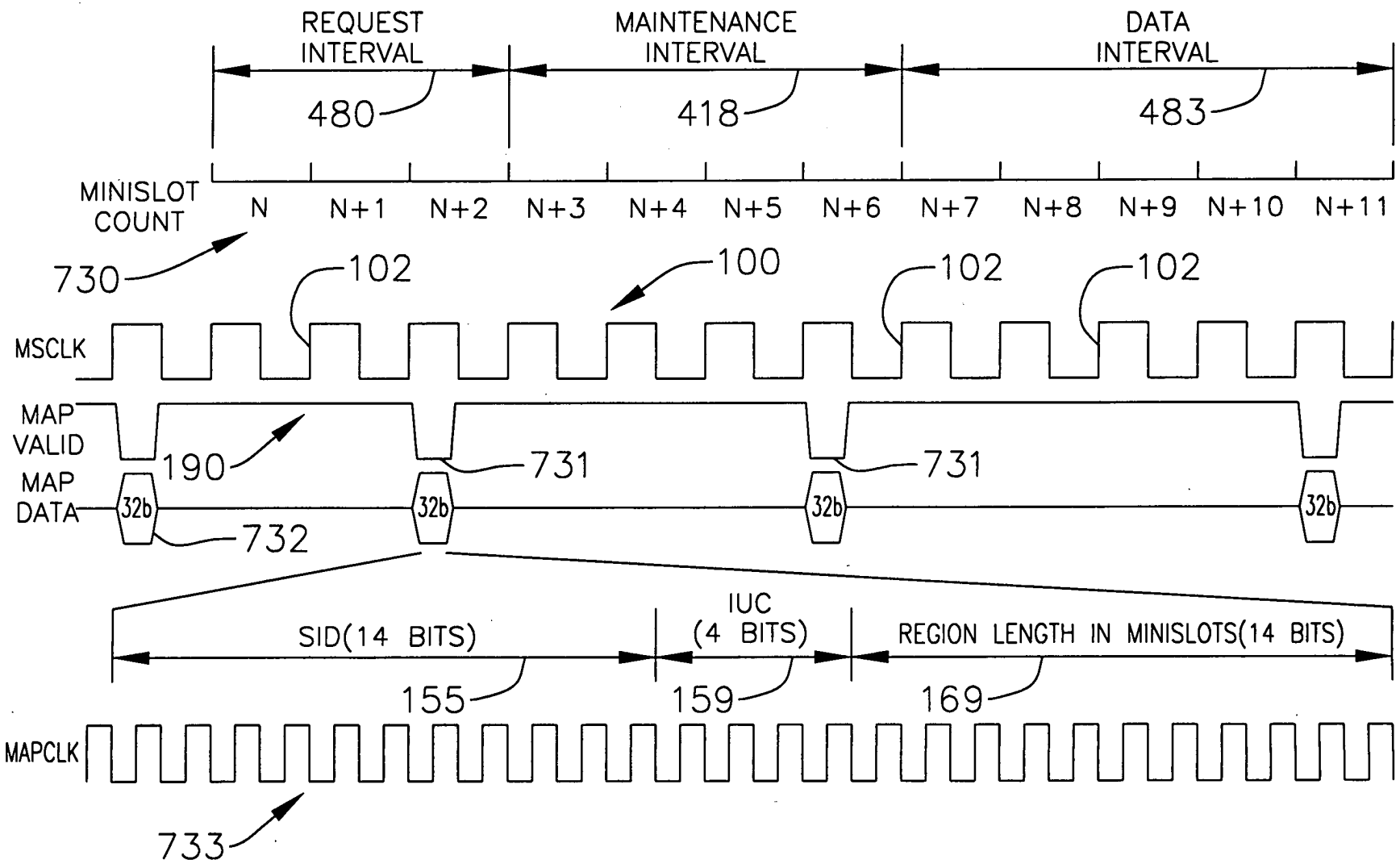
REQUEST INTERVAL
MAINTENANCE INTERVAL
DATA INTERVAL
480
418
483
MINISLOT COUNT
N
N+1
N+2
N+3
N+4
N+5
N+6
N+7
N+8
N+9
N+10
N+11
730
102
100
102
102
MSCLK
MAP VALID
190
731
731
MAP DATA
32b
32b
32b
32b
732
SID(14 BITS)
IUC (4 BITS)
REGION LENGTH IN MINISLOTS(14 BITS)
155
159
169
MAPCLK
733

FIG. 49

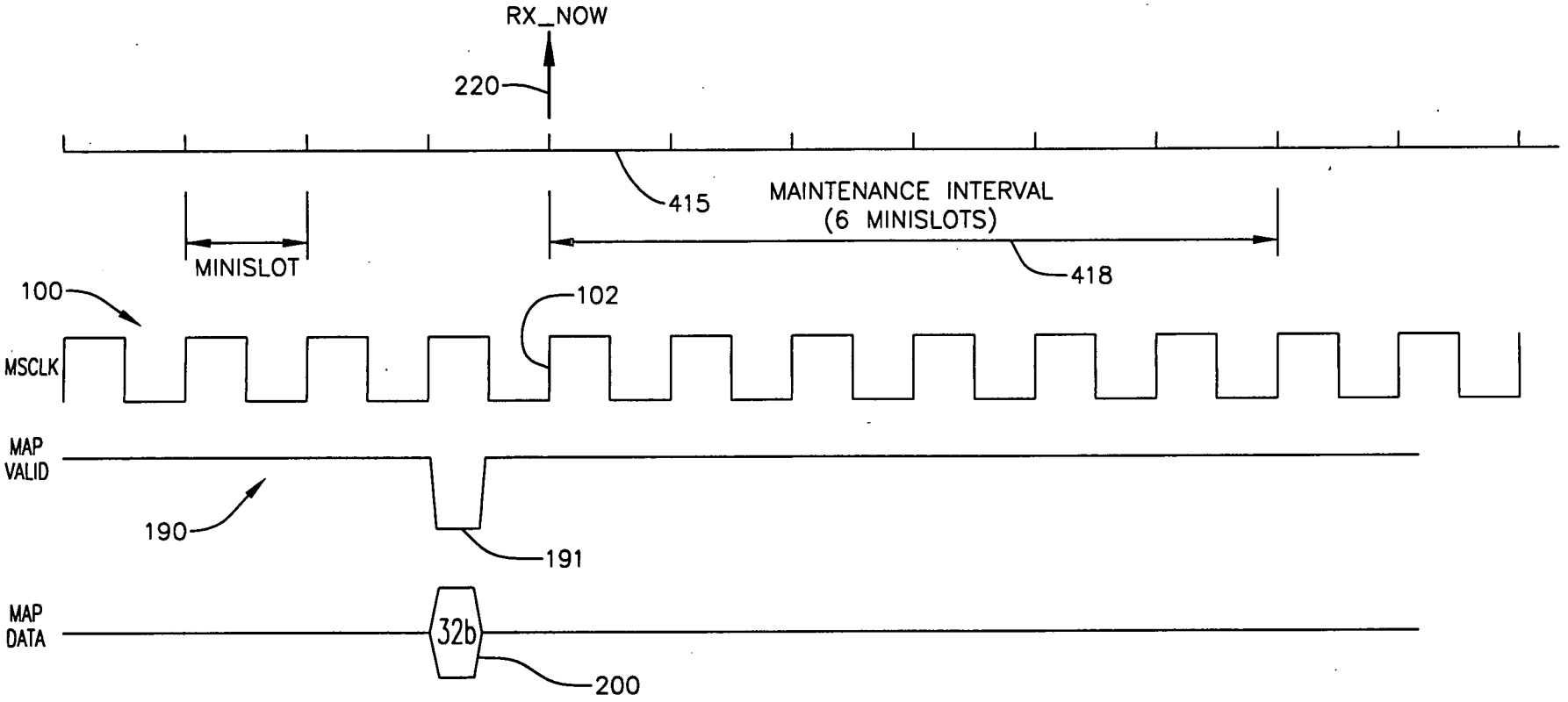
RX_NOW
220
415
MAINTENANCE INTERVAL
(6 MINISLOTS)
418
MINISLOT
100
102
MSCLK
MAP
VALID
190
191
MAP
DATA
32b
200

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FIG.50

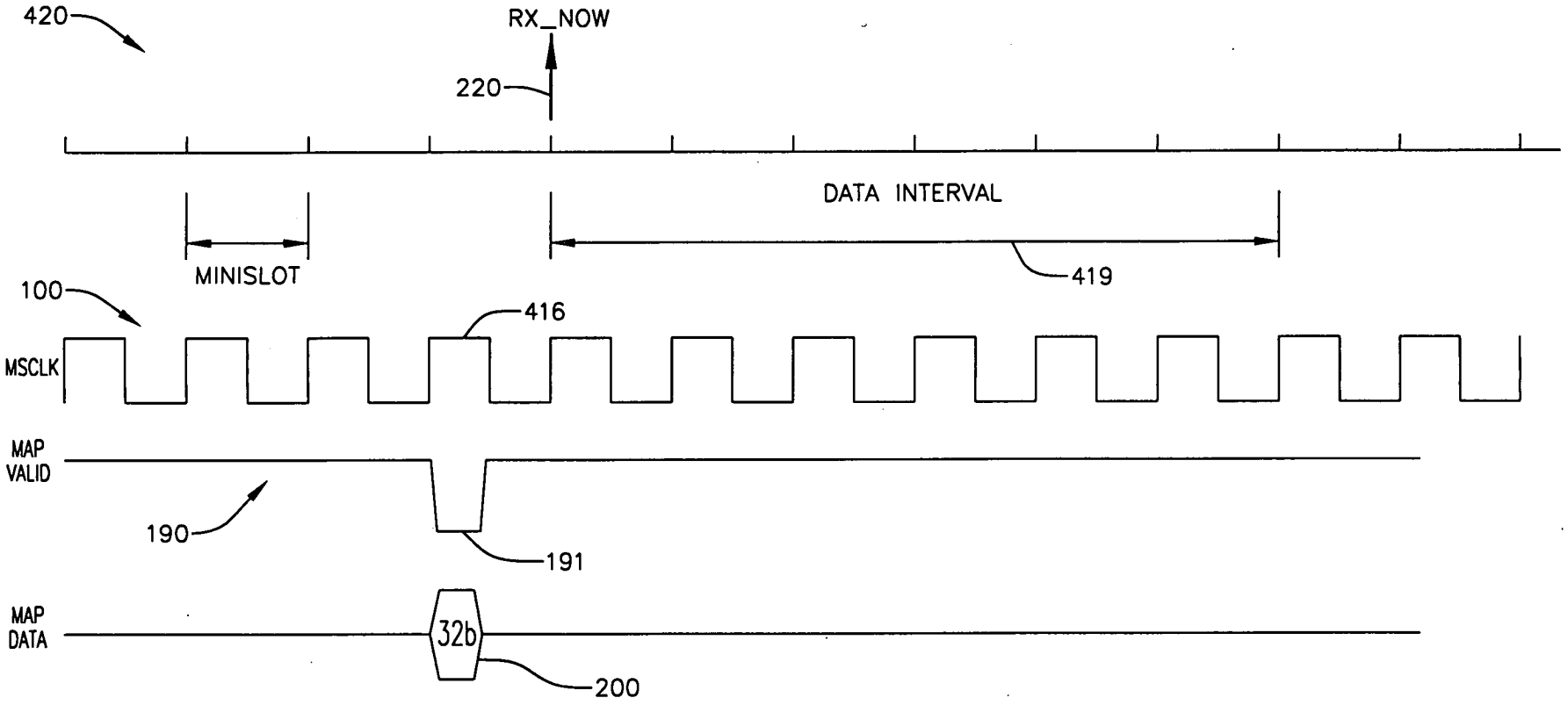

FIG.51

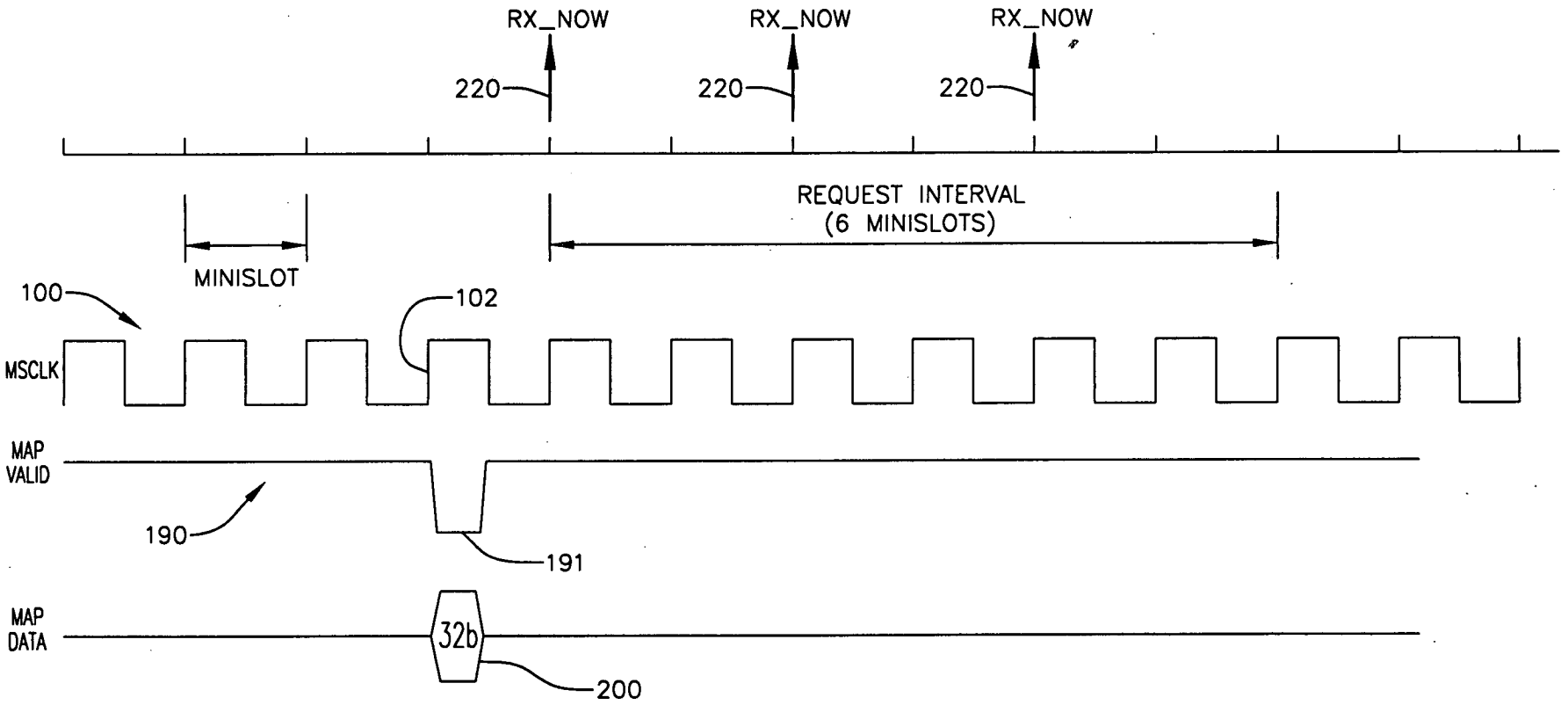
RX_NOW
RX_NOW
RX_NOW
220
220
220
REQUEST INTERVAL
(6 MINISLOTS)
MINISLOT
100
102
MSCLK
MAP
VALID
190
191
MAP
DATA
32b
200

FIG.52

RNG. OFFSET 7 BYTES

STATUS 2 BYTES	TIMESTAMP 4 BYTES	CH. ID 1 BYTE	SID 2 BYTES	PWR. 2 BYTES	FREQ. 2 BYTES	TIME 3 BYTES

FIG.53

RNG. OFFSET 7 BYTES

STATUS 2 BYTES	TIMESTAMP 4 BYTES	CH. ID 1 BYTE	SID 2 BYTES	PWR. 2 BYTES	FREQ. 2 BYTES	TIME 3 BYTES	EQUALIZER COEFFS. 32 BYTES

FIG.54

BASED ON THE STATUS BYTES[7:5] BITS, THE FOLLOWING STATISTICS ARE KEPT USING COUNTERS.

SLOT DEFINITION	STATISTICS	CALCULATION
DATA	1.NUMBER OF SLOTS 2.NUMBER OF SLOTS WITH POWER BUT NO DATA 3.NUMBER OF SLOTS WITH BAD DATA 4.NUMBER OF GOOD DATA-SLOTS 5.TOTAL NUMBER OF FEC BLOCKS 6.NUMBER OF FEC BLOCKS WITH CORRECTABLE ERRORS. 7.NUMBER OF UNCORRECTABLE FEC BLOCKS	NO UW UW AND (BAD FEC OR BAD HEC) UW AND GOOD HEC
REQUEST(CONTENTION)	1.NUMBER OF REQUESTS RECEIVED 2.NUMBER OF COLLIDED REQUESTS 3.NUMBER OF CORRUPTED REQUESTS	NO UW NO UW OR BAD FEC OR BAD HEC
REQUEST/DATA (CONTENTION)	1.NUMBER OF PACKETS RECEIVED 2.NUMBER OF COLLIDED PACKETS 3.NUMBER OF CORRUPTED PACKETS	NO UW NO UW OR BAD FEC OR BAD HEC
RANGING	1.NUMBER OF RANGING MESSAGES RECEIVED 2.NUMBER OF COLLIDED RANGING MESSAGES RECEIVED 3.NUMBER OF CORRUPTED RANGING MESSAGES	NO UW NO UW OR BAD FEC OR BAD HEC

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FIG.55

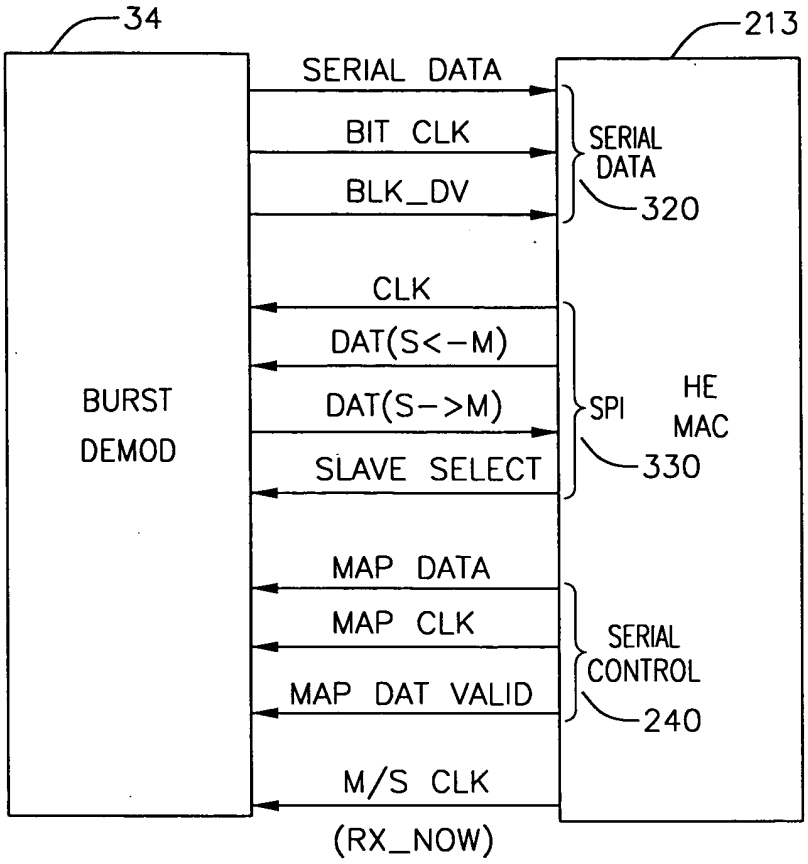


FIG.56

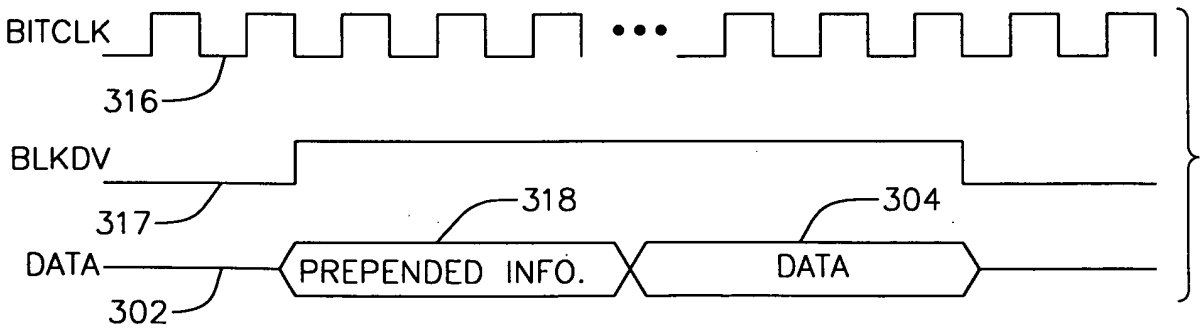


FIG.57

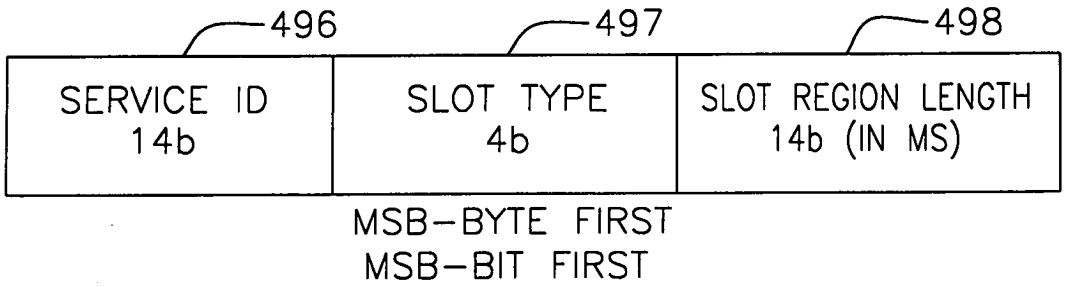


FIG.58

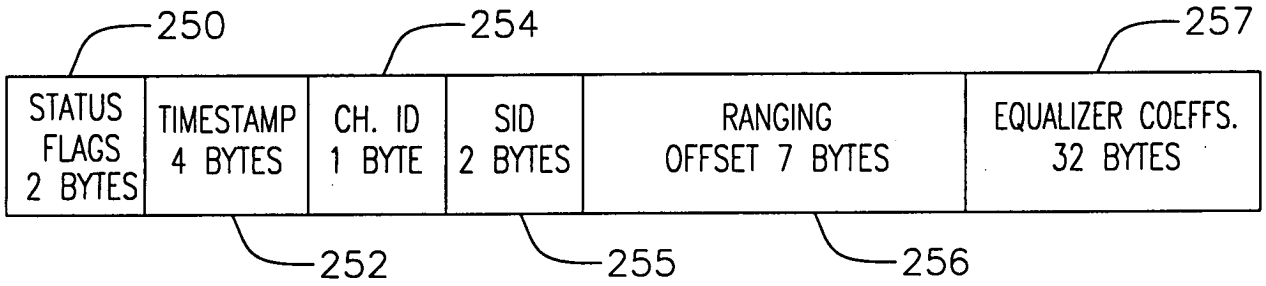


FIG.59

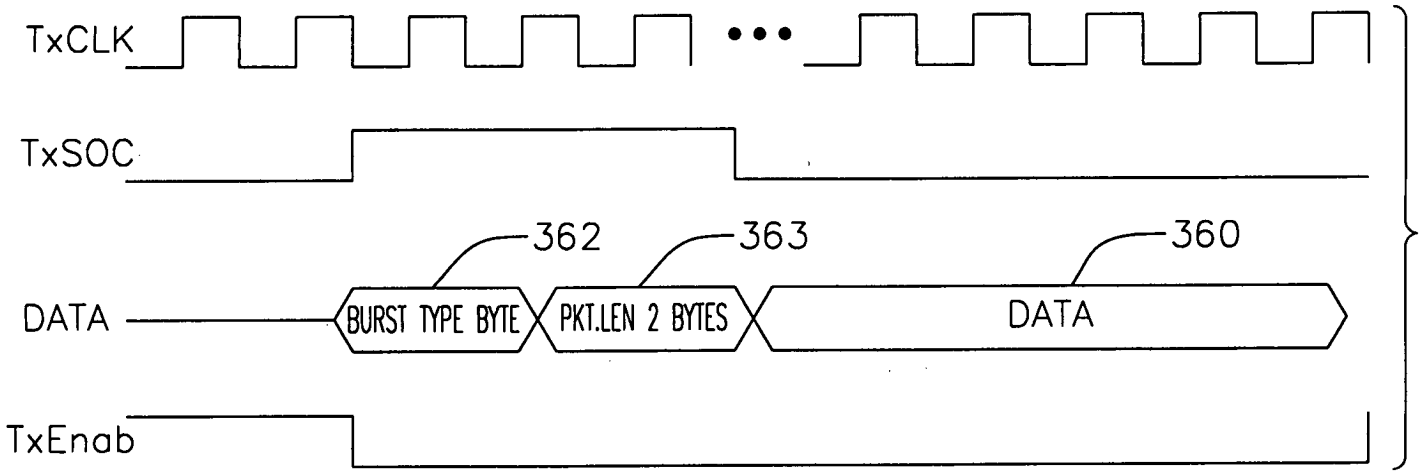


FIG.60

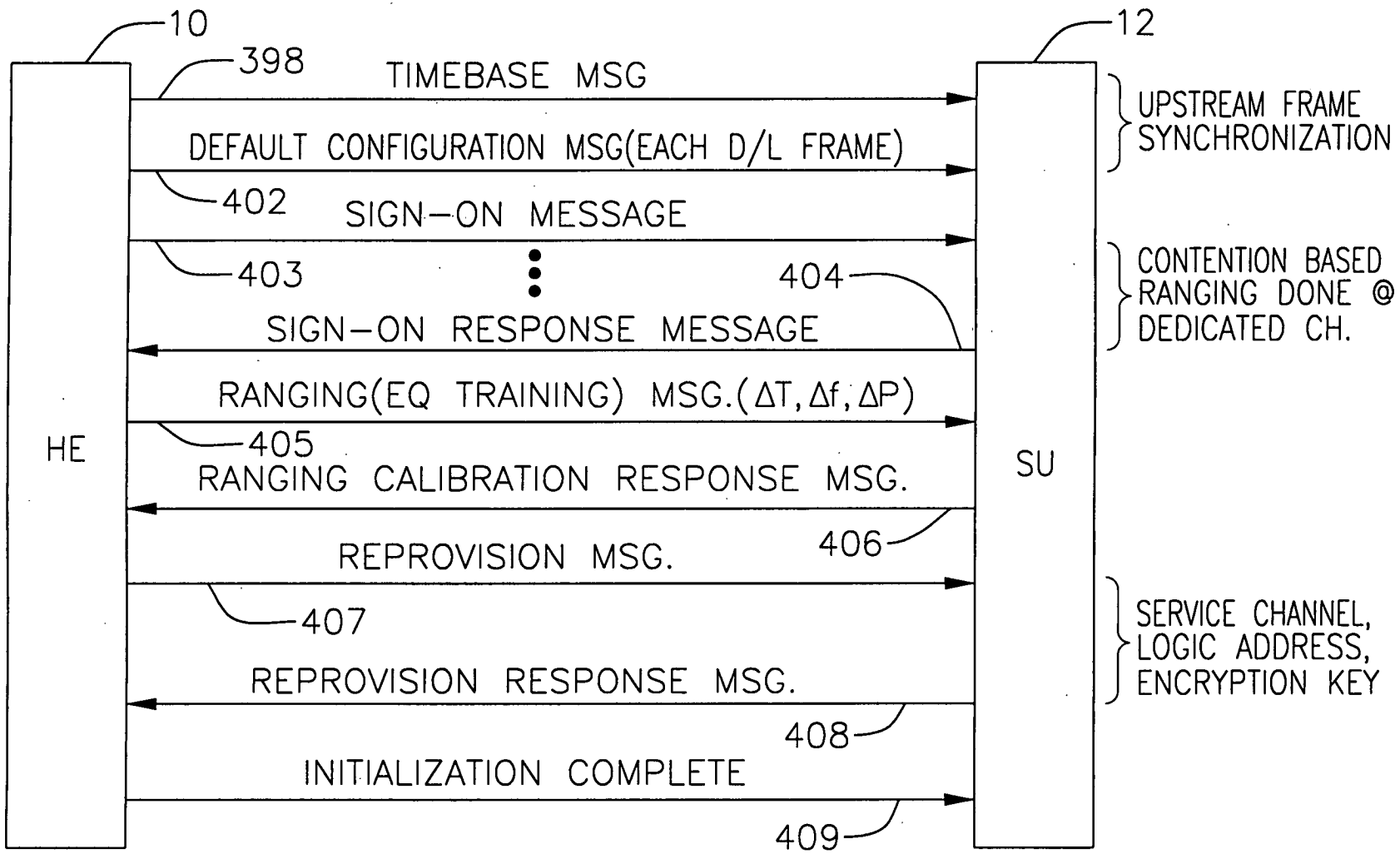
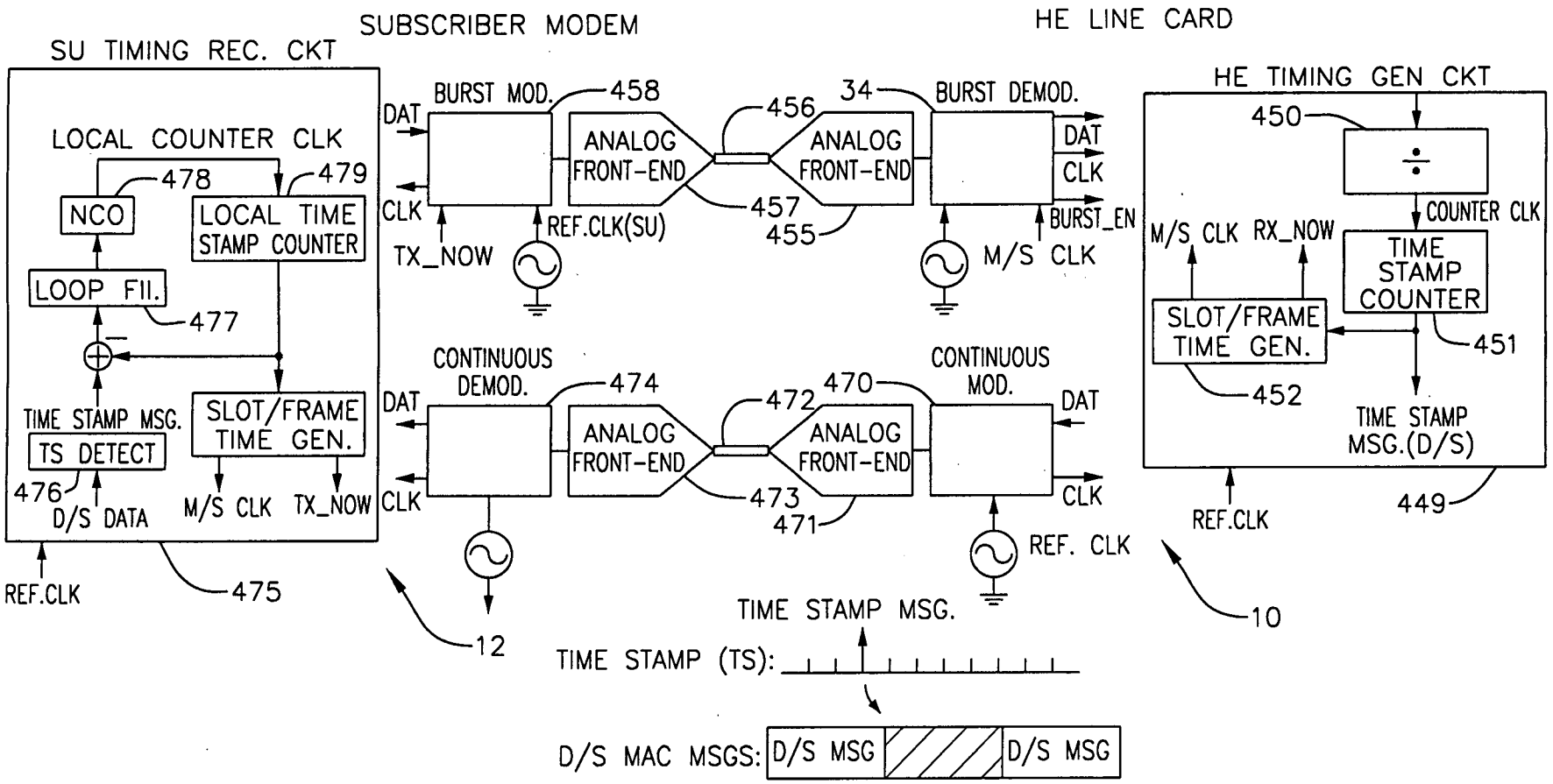

10
12
398
TIMEBASE MSG
DEFAULT CONFIGURATION MSG(EACH D/L FRAME)
UPSTREAM FRAME SYNCHRONIZATION
402
SIGN–ON MESSAGE
403
404
SIGN–ON RESPONSE MESSAGE
CONTENTION BASED RANGING DONE @ DEDICATED CH.
RANGING(EQ TRAINING) MSG.(ΔT, Δf, ΔP)
HE
405
RANGING CALIBRATION RESPONSE MSG.
SU
406
REPROVISION MSG.
407
REPROVISION RESPONSE MSG.
SERVICE CHANNEL, LOGIC ADDRESS, ENCRYPTION KEY
408
INITIALIZATION COMPLETE
409

FIG. 61


SUBSCRIBER MODEM
HE LINE CARD
SU TIMING REC. CKT
LOCAL COUNTER CLK
478
479
NCO
LOCAL TIME STAMP COUNTER
LOOP FII.
477
TIME STAMP MSG.
TS DETECT
476
D/S DATA
SLOT/FRAME TIME GEN.
M/S CLK
TX_NOW
REF.CLK
475
12
BURST MOD.
458
DAT
CLK
TX_NOW
REF.CLK(SU)
ANALOG FRONT-END
456
457
455
ANALOG FRONT-END
34
BURST DEMOD.
DAT
CLK
BURST_EN
M/S CLK
CONTINUOUS DEMOD.
474
DAT
CLK
ANALOG FRONT-END
472
473
471
ANALOG FRONT-END
470
CONTINUOUS MOD.
DAT
CLK
REF. CLK
HE TIMING GEN CKT
450
COUNTER CLK
M/S CLK
RX_NOW
TIME STAMP COUNTER
451
SLOT/FRAME TIME GEN.
452
TIME STAMP MSG.(D/S)
REF.CLK
449
10
TIME STAMP MSG.
TIME STAMP (TS):
D/S MAC MSGS:
D/S MSG
D/S MSG

DOCKET NO. 95-0050-1-US

FIG.62

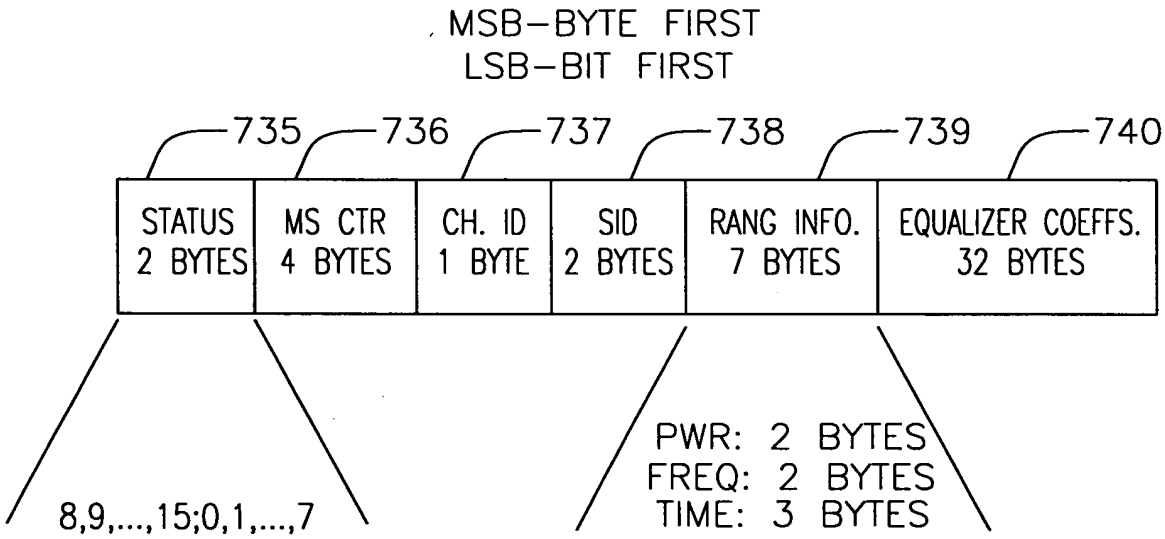


FIG.63

BIT FIELD	DEFINITION IF BIT[11]=1	DEFINITION IF BIT[11]=0
BIT[15:12]	DOCSIS IUC	RESERVED
BIT[11]	1:INDICATES 1ST. BLOCK OF TRANSMISSION	0:INDICATES NOT 1ST. BLOCK OF TRANSMISSION
BIT[10]	1:INDICATES LAST BLOCK OF TRANSMISSION	1:INDICATES LAST BLOCK OF TRANSMISSION
BIT[9]	1:INDICATES RANGING REQUIRED	RESERVED
BIT[8]	RESERVED	RESERVED
BIT[7:5]	000:FEC OK 001:CORRECTABLE FEC ERROR 010:UNCORRECTABLE FEC ERROR 011:NO UNIQUE WORD DETECTED 100:COLLIDED PACKET 101:NO ENERGY 110:PACKET LENGTH VIOLATION	000:FEC OK 001:CORRECTABLE FEC ERROR 010:UNCORRECTABLE FEC ERROR 011:NO UNIQUE WORD DETECTED 100:COLLIDED PACKET 101:NO ENERGY 110:PACKET LENGTH VIOLATION
BIT[4]	1:VALID MINISLOT COUNT PREPENDED	RESERVED
BIT[3]	1:VALID CHANNEL ID PREPENDED	RESERVED
BIT[2]	1:VALID SID PREPENDED	RESERVED
BIT[1]	1:RANGING INFO PREPENDED	RESERVED
BIT[0]	1:EQUALIZER COEFFICIENTS PREPENDED	RESERVED

FIG.64

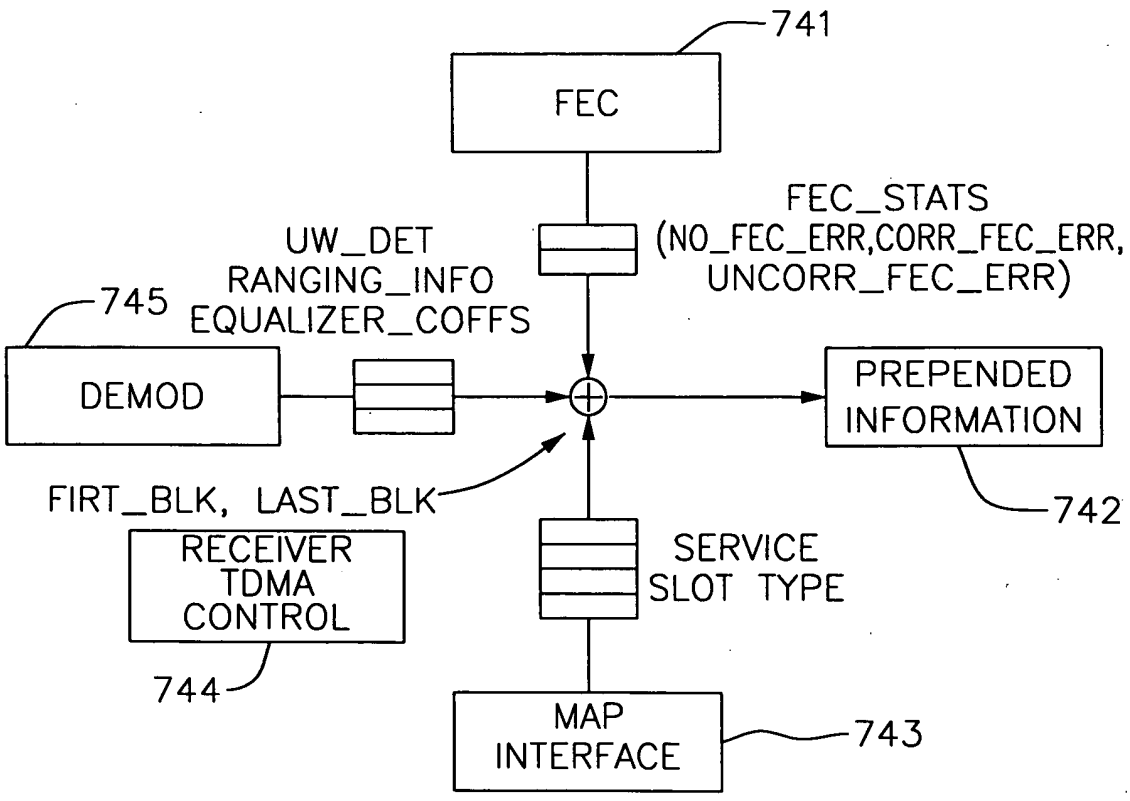

741
FEC
FEC_STATS
(NO_FEC_ERR,CORR_FEC_ERR,
UNCORR_FEC_ERR)
UW_DET
RANGING_INFO
EQUALIZER_COFFS
745
DEMOD
PREPENDED
INFORMATION
742
FIRT_BLK, LAST_BLK
RECEIVER
TDMA
CONTROL
744
SERVICE
SLOT TYPE
MAP
INTERFACE
743

FIG. 65

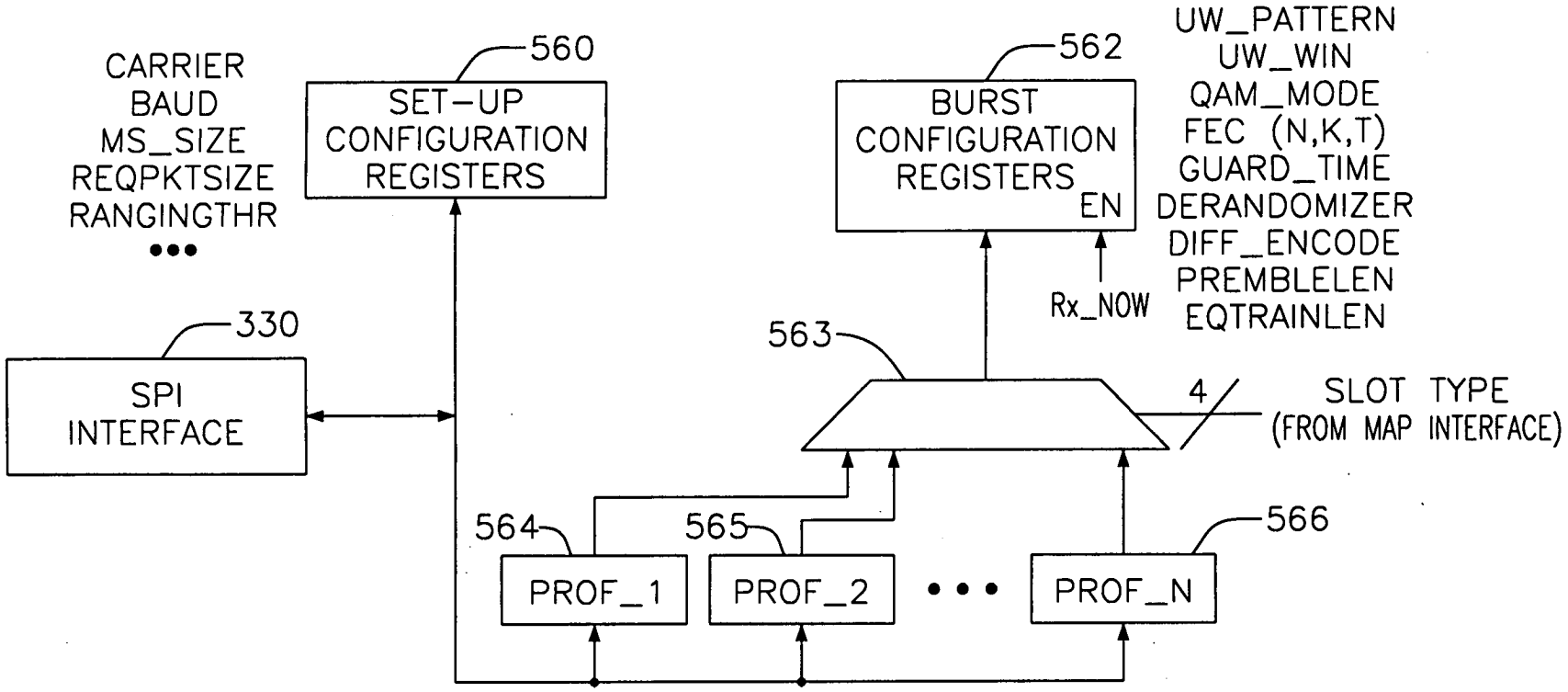

CARRIER
BAUD
MS_SIZE
REQPKTSIZE
RANGINGTHR
•••
560
SET–UP
CONFIGURATION
REGISTERS
330
SPI
INTERFACE
562
BURST
CONFIGURATION
REGISTERS
EN
UW_PATTERN
UW_WIN
QAM_MODE
FEC (N,K,T)
GUARD_TIME
DERANDOMIZER
DIFF_ENCODE
PREMBLELEN
EQTRAINLEN
Rx_NOW
563
4
SLOT TYPE
(FROM MAP INTERFACE)
564
565
566
PROF_1
PROF_2
• • •
PROF_N

FIG.66

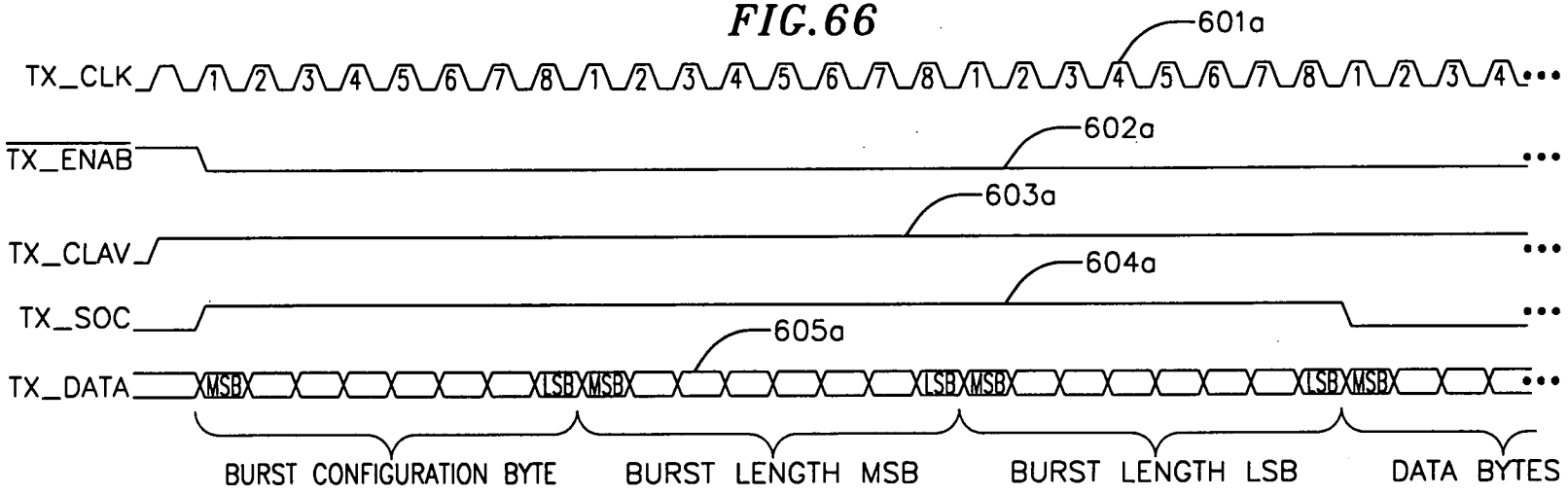

601a
TX_CLK
1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3 4
602a
TX_ENAB
603a
TX_CLAV
604a
TX_SOC
605a
TX_DATA
MSB LSB MSB LSB MSB LSB MSB LSB
BURST CONFIGURATION BYTE
BURST LENGTH MSB
BURST LENGTH LSB
DATA BYTES

FIG.67

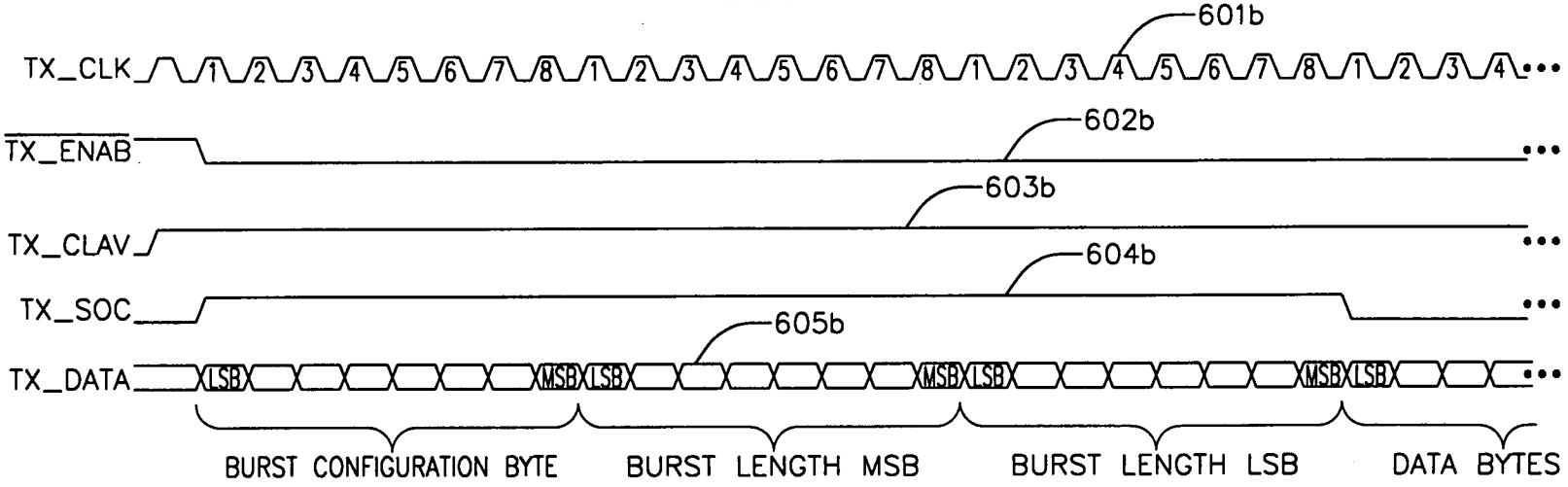
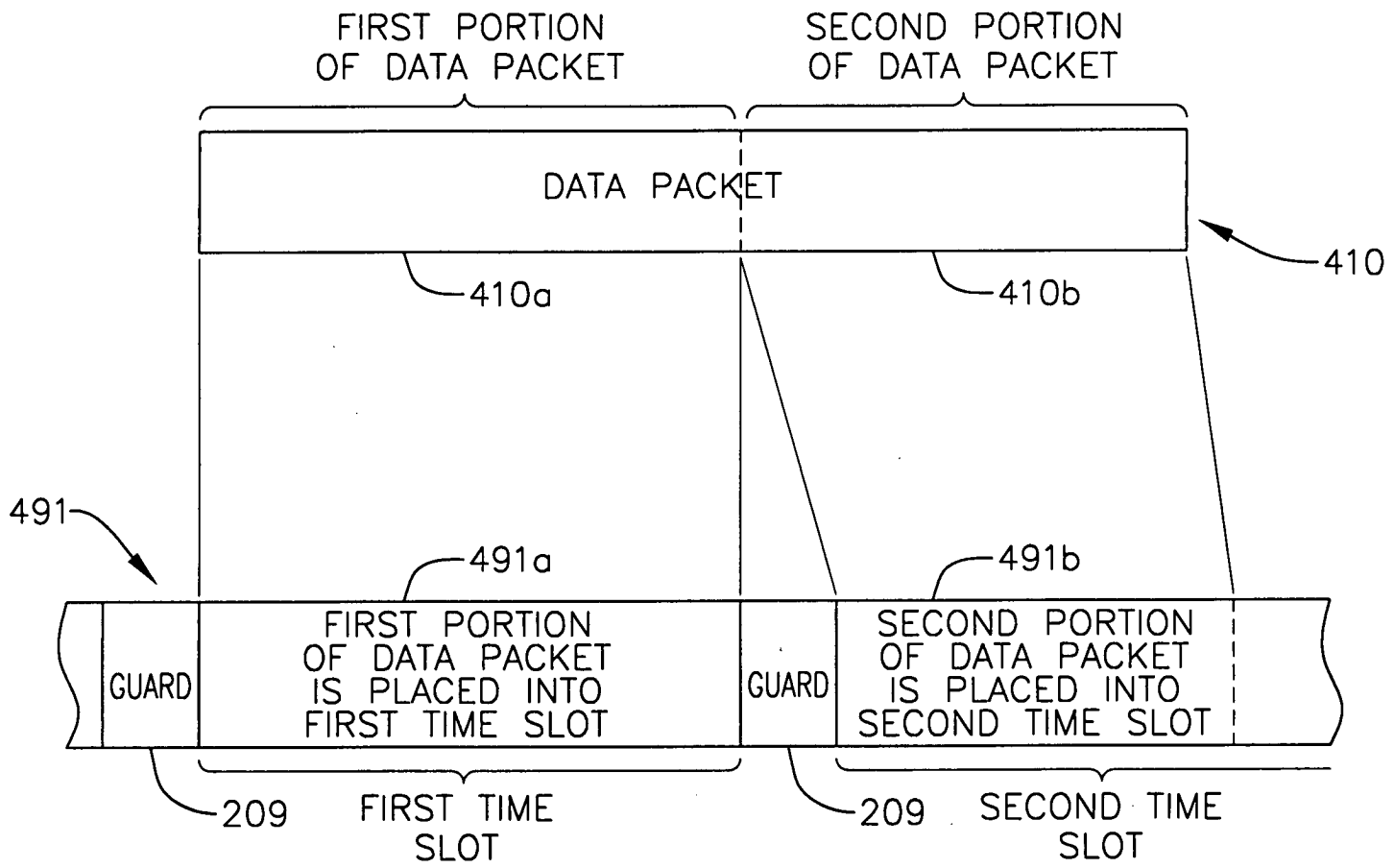

601b
TX_CLK
1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3 4
602b
TX_ENAB
603b
TX_CLAV
604b
TX_SOC
605b
TX_DATA
LSB MSB LSB MSB LSB MSB LSB MSB
BURST CONFIGURATION BYTE
BURST LENGTH MSB
BURST LENGTH LSB
DATA BYTES

FIG.68


FIRST PORTION OF DATA PACKET
SECOND PORTION OF DATA PACKET
DATA PACKET
410
410a
410b
491
491a
491b
GUARD
FIRST PORTION OF DATA PACKET IS PLACED INTO FIRST TIME SLOT
GUARD
SECOND PORTION OF DATA PACKET IS PLACED INTO SECOND TIME SLOT
209
FIRST TIME SLOT
209
SECOND TIME SLOT

DOCKET ALARM

FIG.69

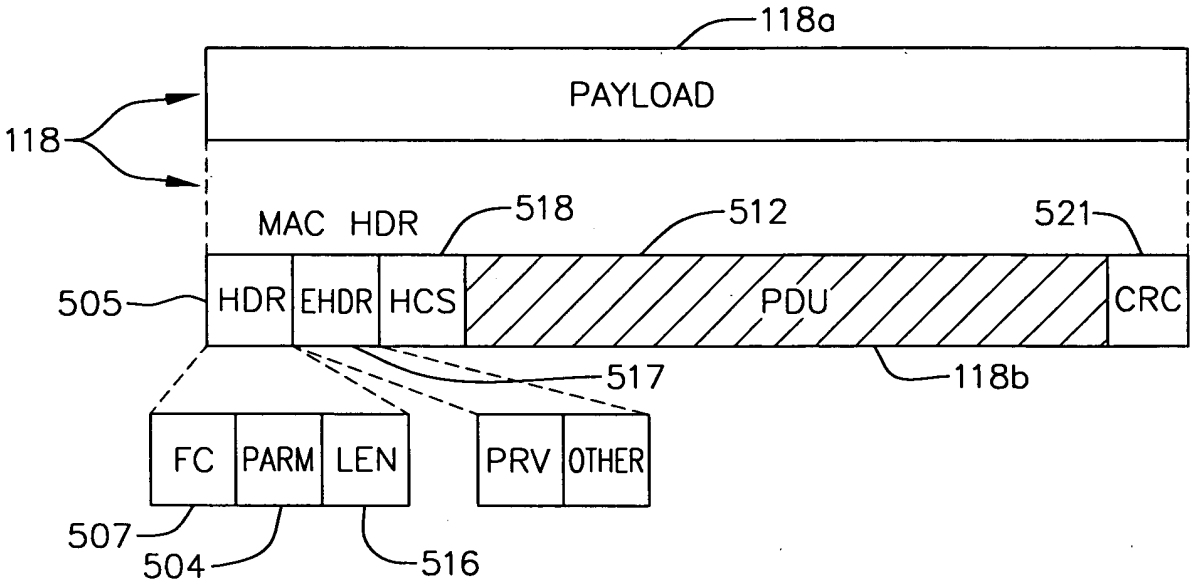
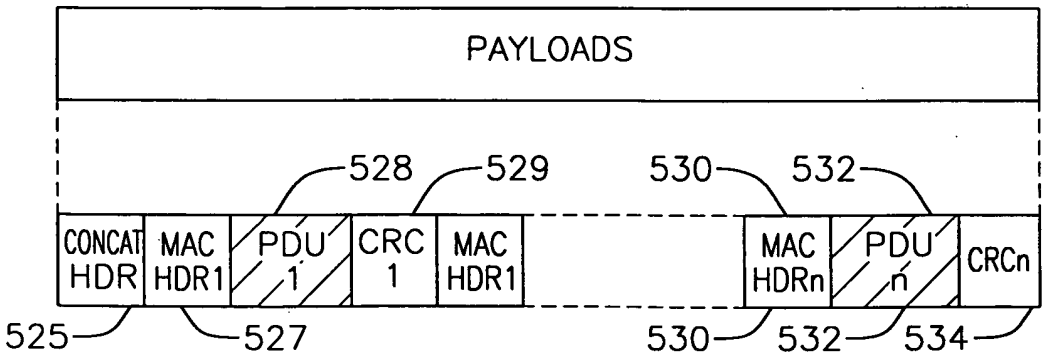


FIG.70



09907 2T24B960

FIG. 71

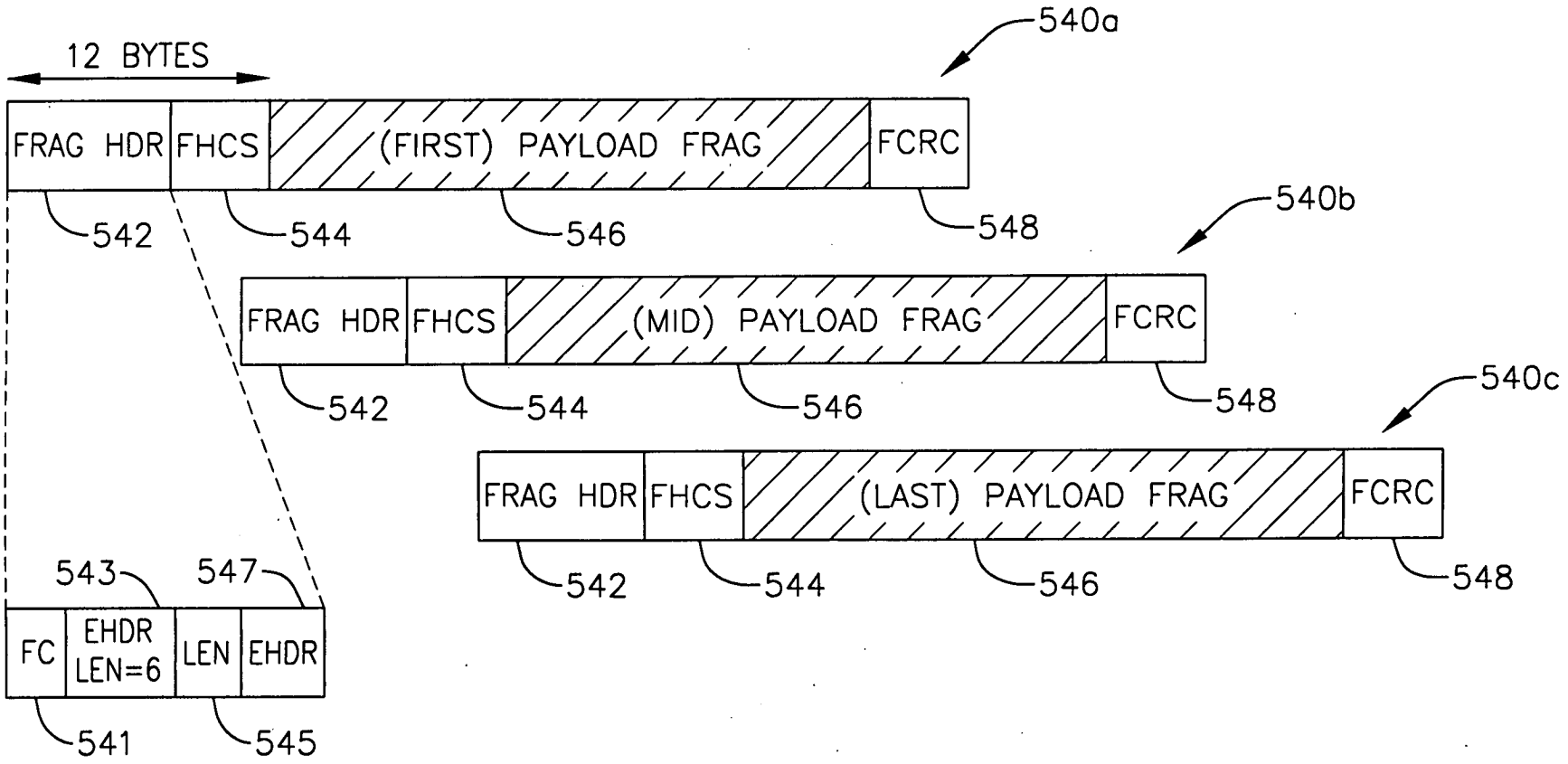


FIG.72

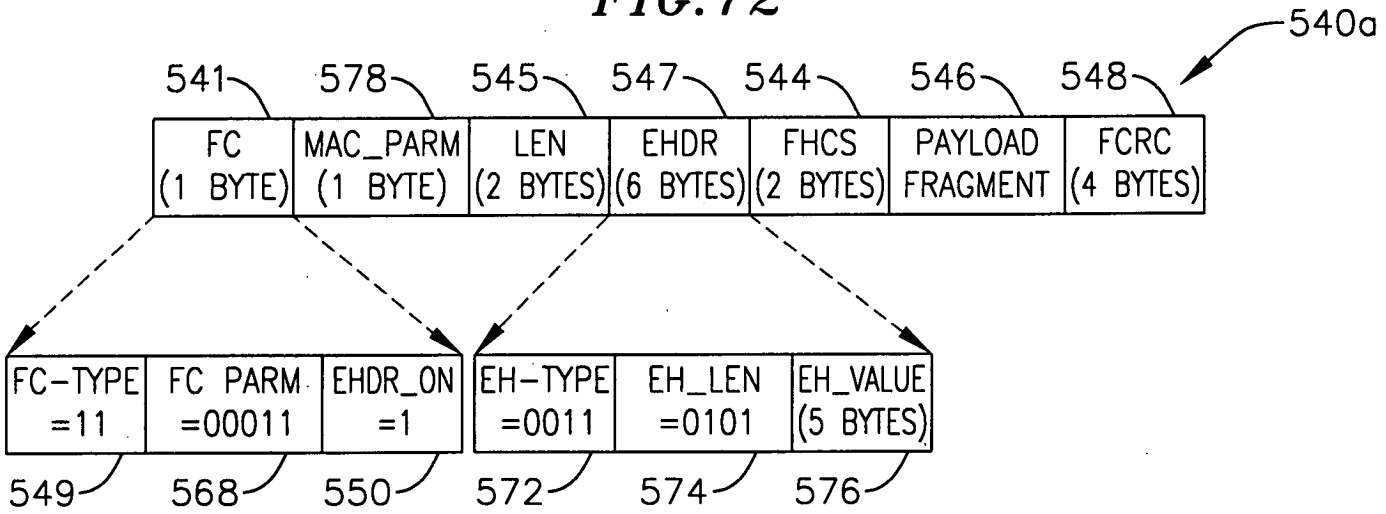


FIG.73

FIELD	USAGE	SIZE
FC	FC_TYPE=11;MAC-SPECIFIC HEADER FC_PARM [4:0]=00011;FRAGMENTATION MAC HEADER EHDR_ON = 1;FRAGMENTATION EHDR FOLLOWS	8 BITS
MAC_PARM	ELEN = 6 BYTES;LENGTH OF FRAGMENTATION EHDR	8 BITS
LEN	LEN = n+10;TOTAL LENGTH OF THIS FRAGMENT INCLUDING PAYLOAD, EHDR, FCRC	16 BITS

FIG.74

FIELD	USAGE	SIZE	
EHDR	EH_TYPE=3;SAME TYPE AS BP_UP EH_LEN=5;LENGTH OF THIS EHDR KEY_SEQ;SAME AS IN BP_UP VER=0001;VERSION NUMBER FOR THIS EHDR ENABLE IF ENABLE=0, BPI DISABLED IF ENABLE=1, BPI ENABLED TOGGLE BIT;SAME AS IN BP_UP SID;SERVICE ID ASSOCIATED WITH THIS FRAGMENT REQ;NUMBER OF MINI-SLOTS FOR A PIGGYBACK REQUEST RESERVED;MUST BE SET TO ZERO FIRST_FRAG;SET TO ONE FOR FIRST FRAGMENT ONLY LAST_FRAG;SET TO ONE FOR LAST FRAGMENT ONLY FRAG_SEQ;FRAGMENT SEQUENCE COUNT, INCREMENTED FOR EACH FRAGMENT, SET TO ZERO FOR FIRST FRAGMENT	4 BITS 4 BITS 4 BITS 4 BITS 1 BIT 1 BIT 14 BITS 8 BITS 2 BITS 1 BIT 1 BIT 4 BITS	6 BYTES
FHCS	MAC HEADER CHECK SEQUENCE		2 BYTES
PAYLOAD	FRAGMENT PAYLOAD;PORTION OF TOTAL MAC PDU BEING SENT		n BYTES
FCRC	CRC ACROSS FRAGMENT PAYLOAD		4 BYTES
	LENGTH OF A MAC FRAGMENT FRAME	n + 16 BYTES	

0090075 27274960

FIG. 75

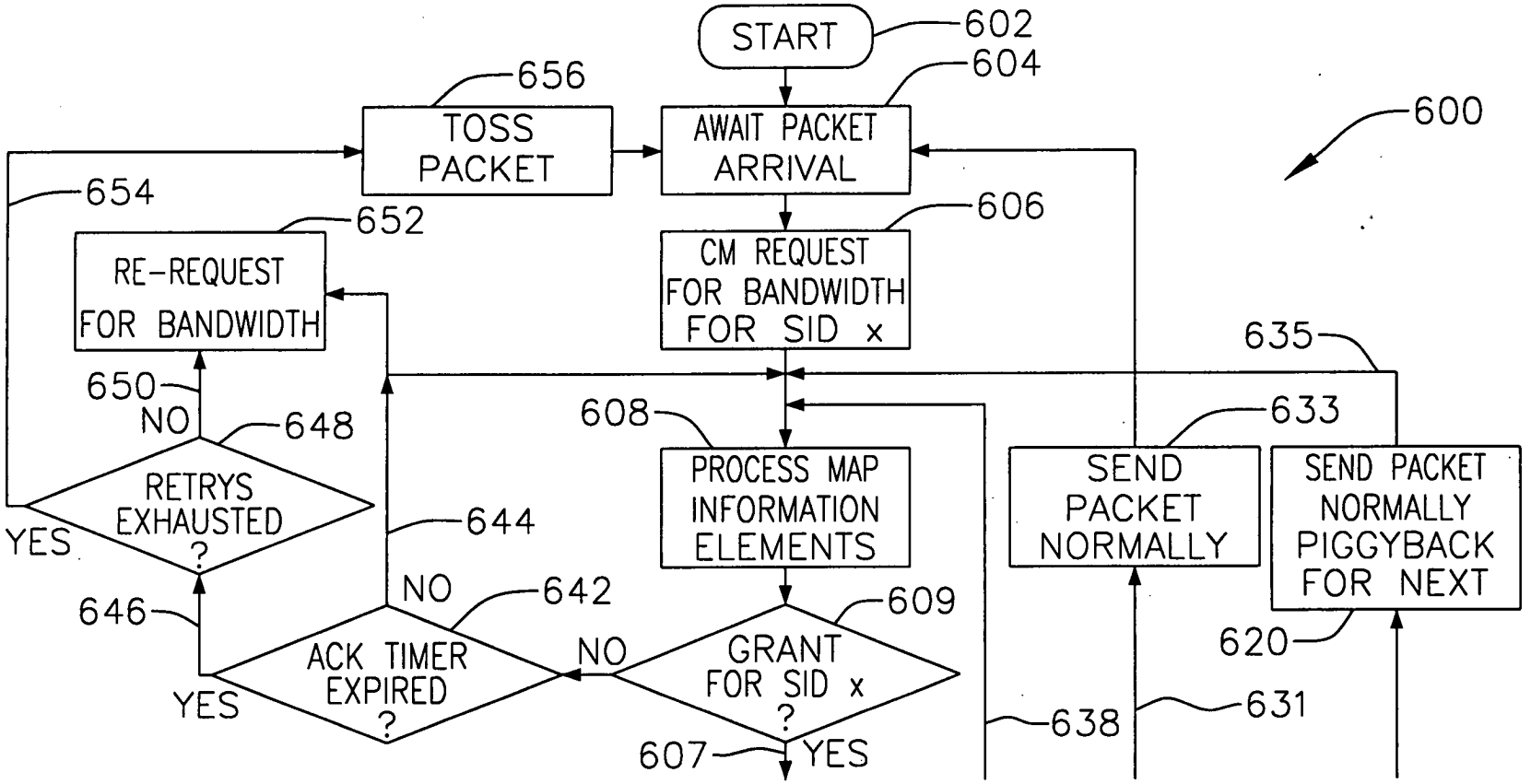


FIG.76

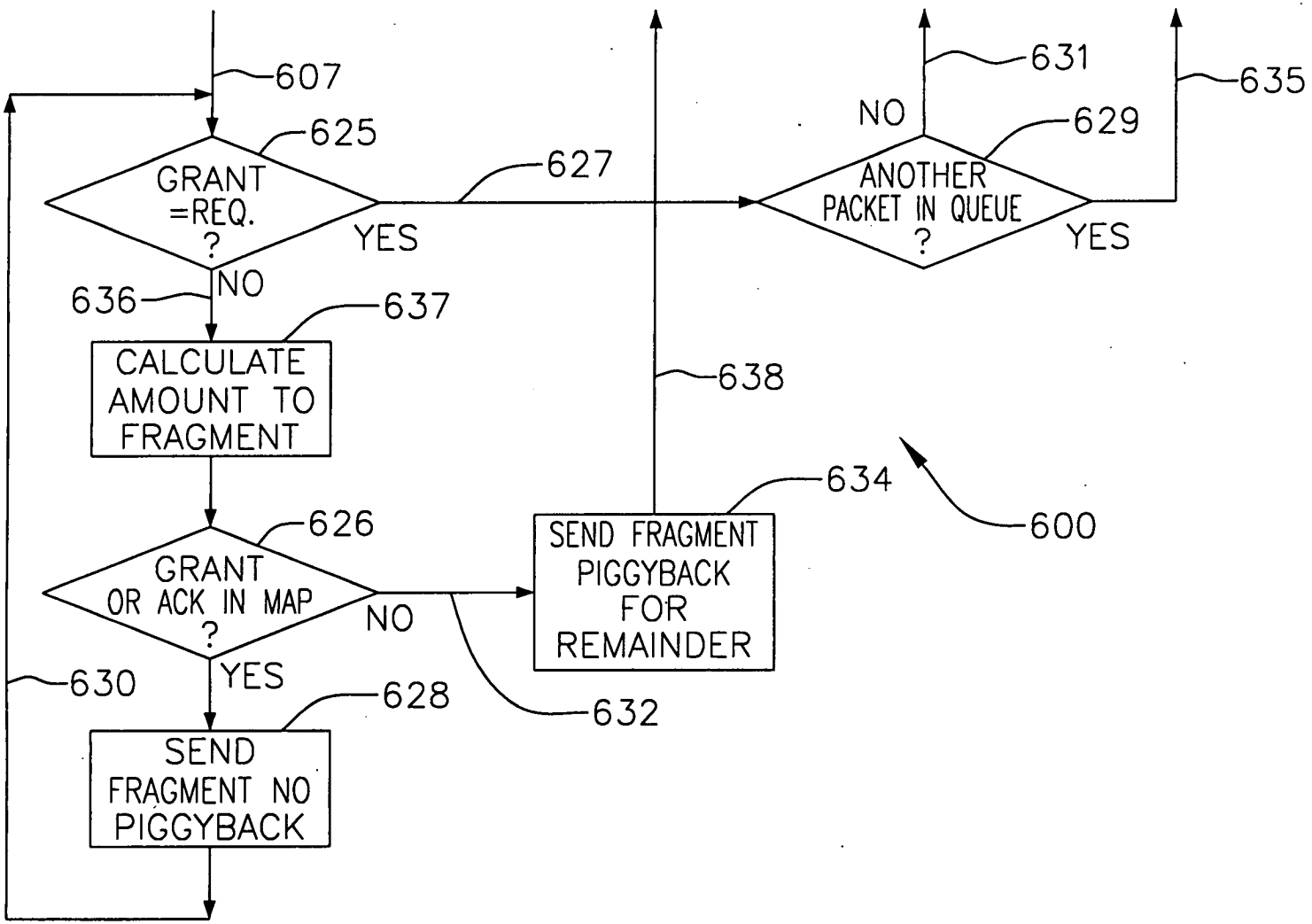

607
625
GRANT =REQ. ?
YES
627
NO
631
635
629
ANOTHER PACKET IN QUEUE ?
YES
636
NO
637
CALCULATE AMOUNT TO FRAGMENT
638
634
600
626
GRANT OR ACK IN MAP ?
NO
SEND FRAGMENT PIGGYBACK FOR REMAINDER
630
YES
628
632
SEND FRAGMENT NO PIGGYBACK

FIG.77

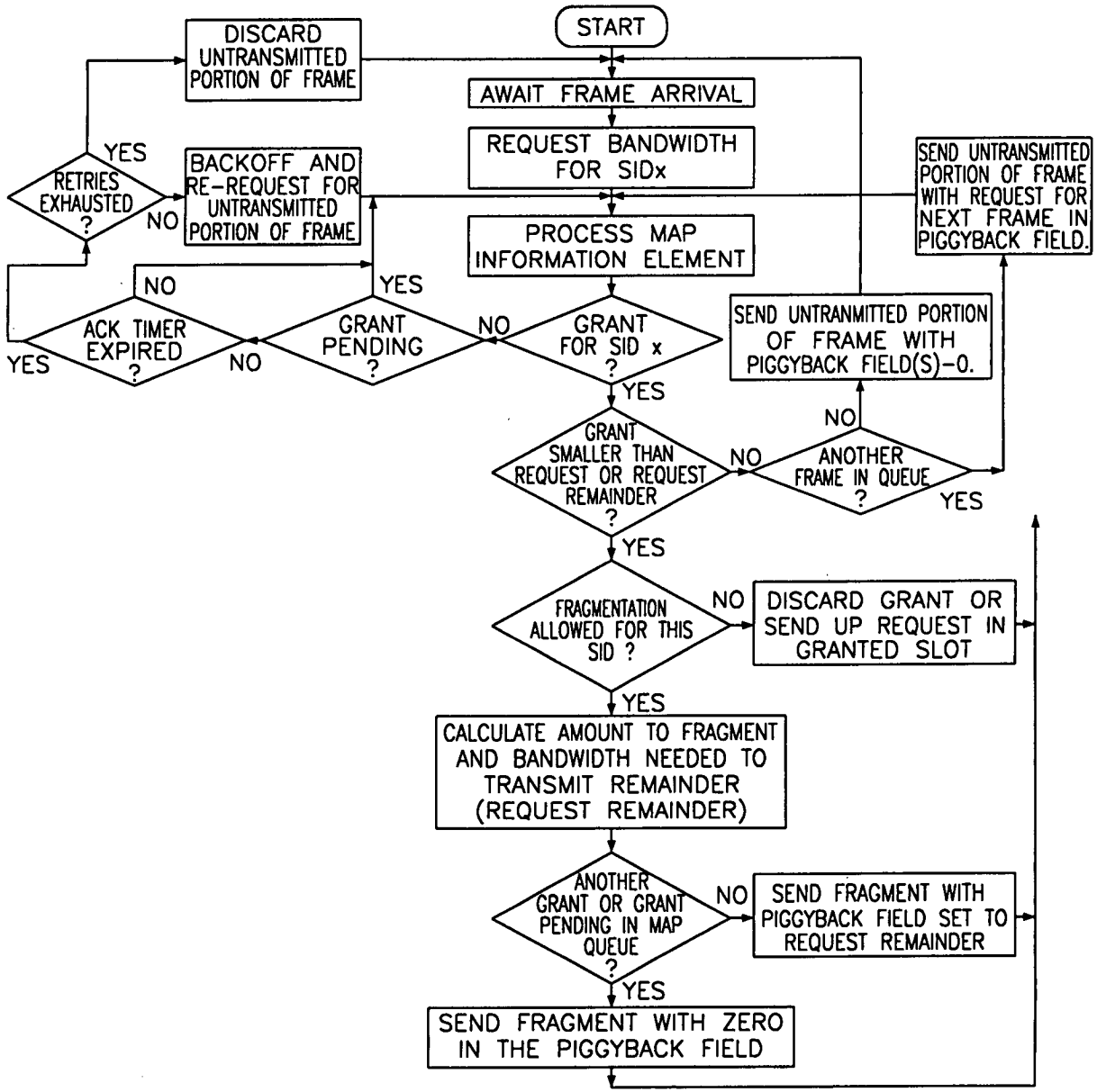

START
AWAIT FRAME ARRIVAL
REQUEST BANDWIDTH FOR SIDx
PROCESS MAP INFORMATION ELEMENT
GRANT FOR SID x ?
NO
YES
SEND UNTRANMITTED PORTION OF FRAME WITH PIGGYBACK FIELD(S)-0.
SEND UNTRANSMITTED PORTION OF FRAME WITH REQUEST FOR NEXT FRAME IN PIGGYBACK FIELD.
ANOTHER FRAME IN QUEUE ?
NO
YES
GRANT SMALLER THAN REQUEST OR REQUEST REMAINDER ?
NO
YES
FRAGMENTATION ALLOWED FOR THIS SID ?
NO
DISCARD GRANT OR SEND UP REQUEST IN GRANTED SLOT
YES
CALCULATE AMOUNT TO FRAGMENT AND BANDWIDTH NEEDED TO TRANSMIT REMAINDER (REQUEST REMAINDER)
ANOTHER GRANT OR GRANT PENDING IN MAP QUEUE ?
NO
SEND FRAGMENT WITH PIGGYBACK FIELD SET TO REQUEST REMAINDER
YES
SEND FRAGMENT WITH ZERO IN THE PIGGYBACK FIELD
GRANT PENDING ?
NO
YES
ACK TIMER EXPIRED ?
NO
YES
RETRIES EXHAUSTED ?
NO
YES
BACKOFF AND RE-REQUEST FOR UNTRANSMITTED PORTION OF FRAME
DISCARD UNTRANSMITTED PORTION OF FRAME

FIG. 78

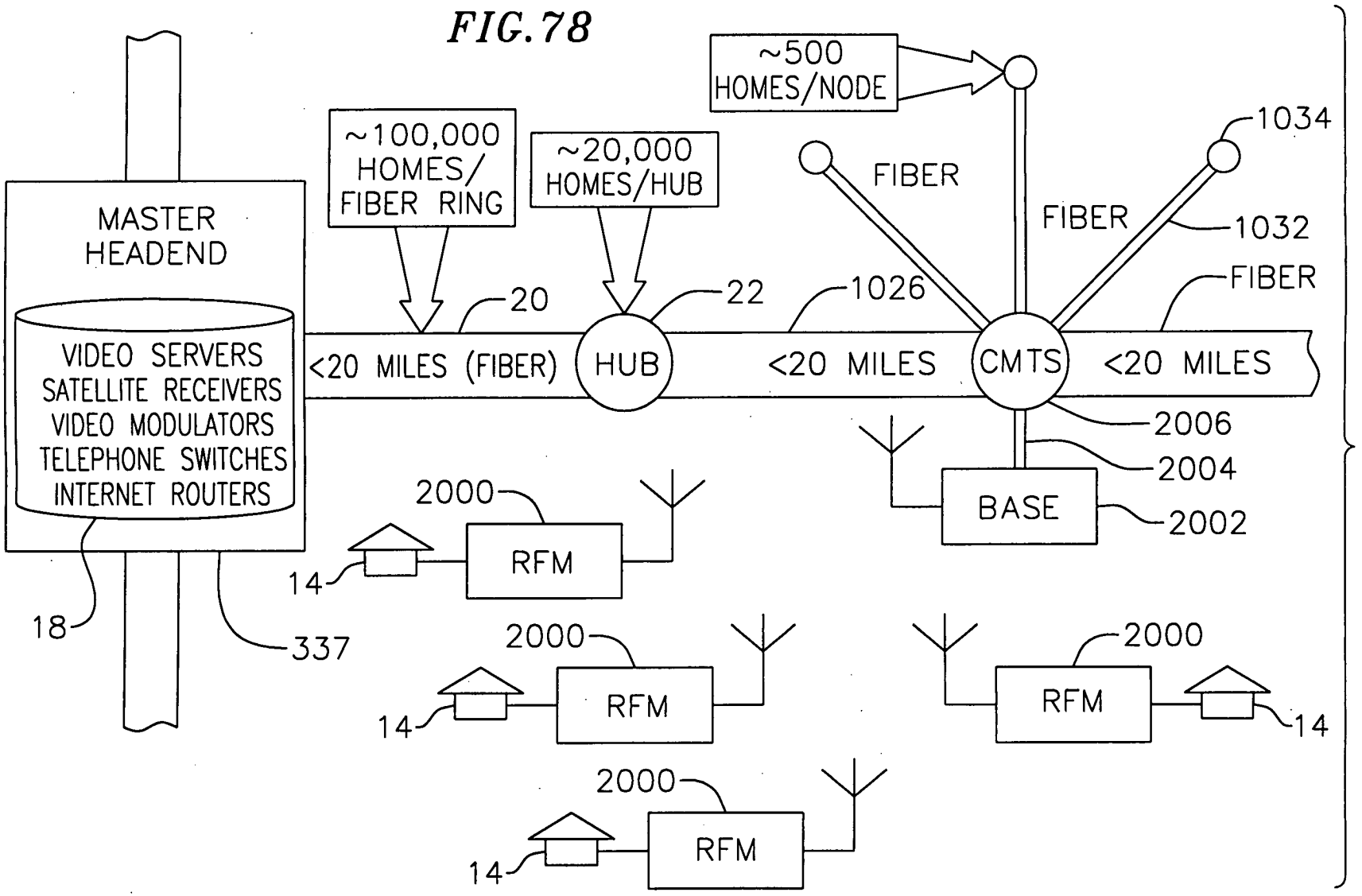

~500
HOMES/NODE
~100,000
HOMES/
FIBER RING
~20,000
HOMES/HUB
FIBER
FIBER
1034
1032
FIBER
MASTER
HEADEND
VIDEO SERVERS
SATELLITE RECEIVERS
VIDEO MODULATORS
TELEPHONE SWITCHES
INTERNET ROUTERS
20
22
1026
<20 MILES (FIBER)
HUB
<20 MILES
CMTS
<20 MILES
2006
2004
BASE
2002
2000
RFM
14
18
337
2000
RFM
14
2000
RFM
14
2000
RFM
14

FIG.79

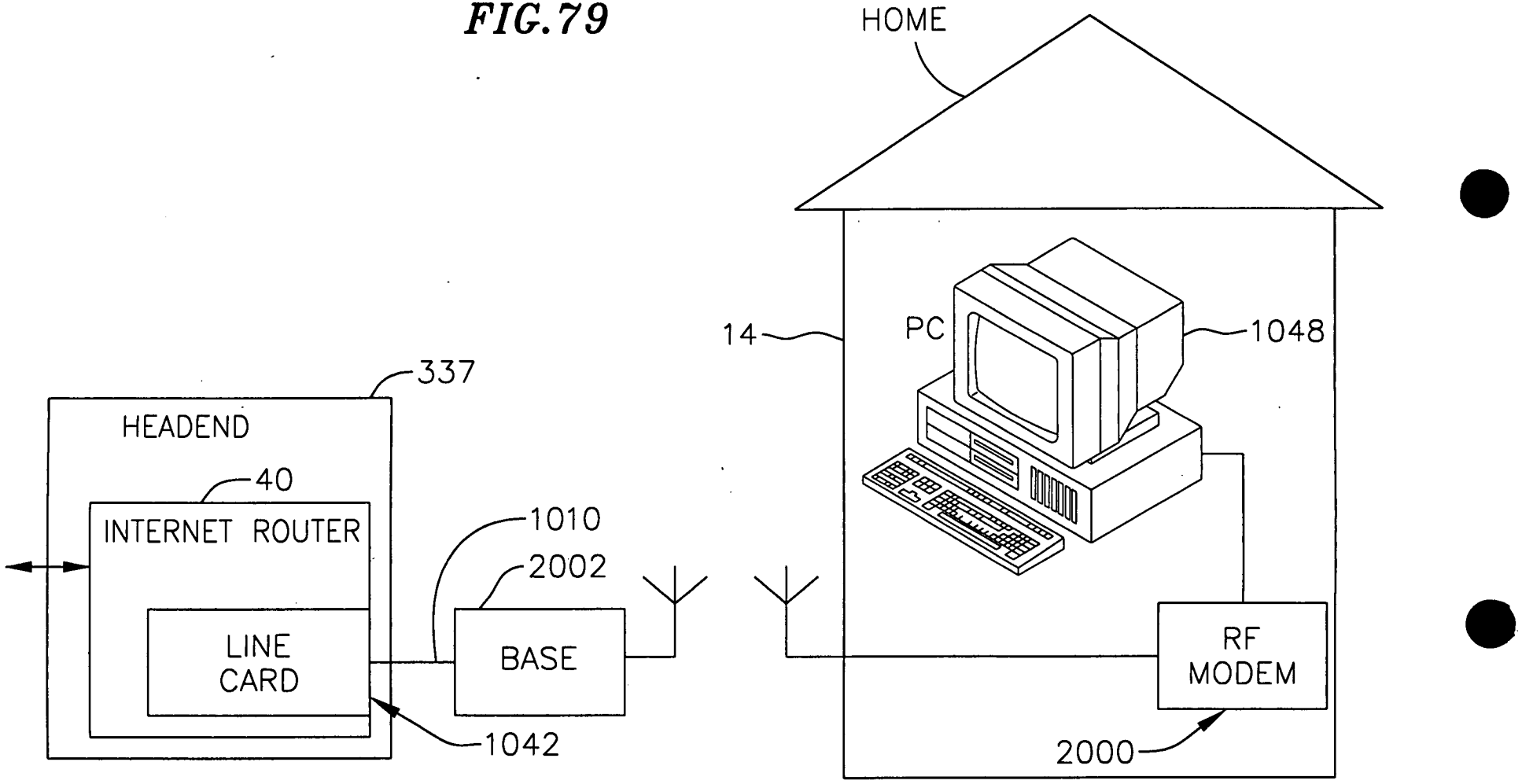

HOME
14
PC
1048
337
HEADEND
40
INTERNET ROUTER
1010
2002
LINE CARD
BASE
RF MODEM
1042
2000

FIG.80

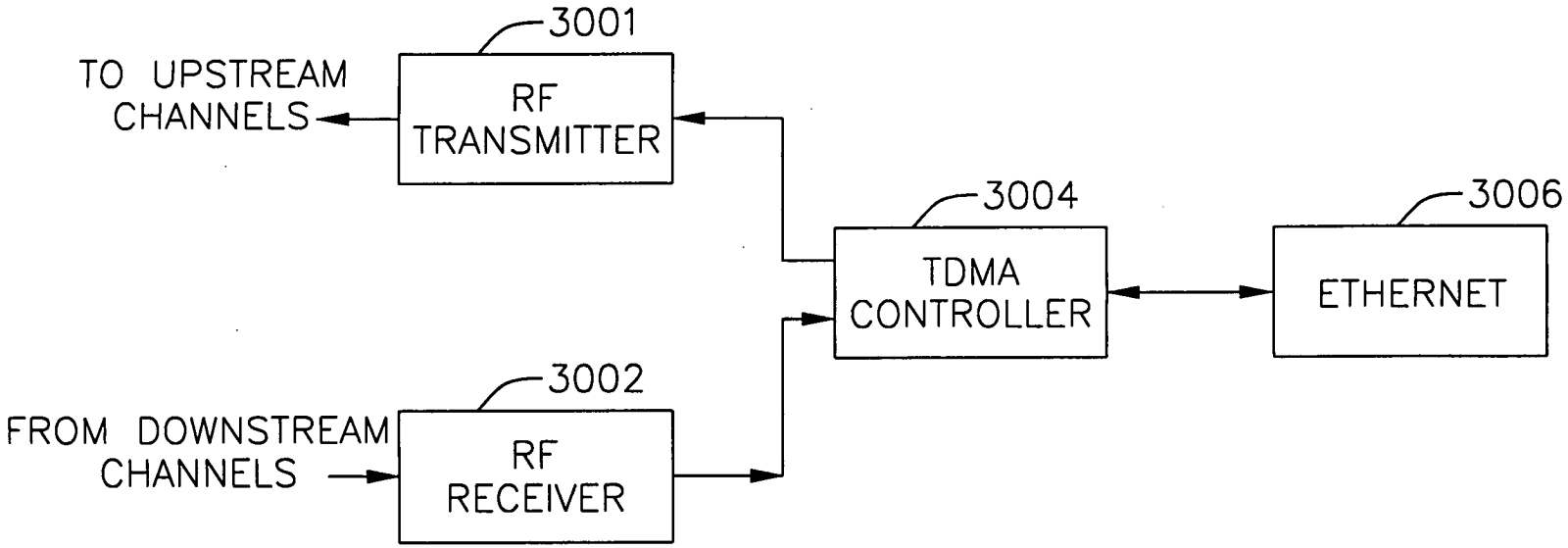

3001
TO UPSTREAM CHANNELS
RF TRANSMITTER
3004
TDMA CONTROLLER
3006
ETHERNET
3002
FROM DOWNSTREAM CHANNELS
RF RECEIVER

FIG.81

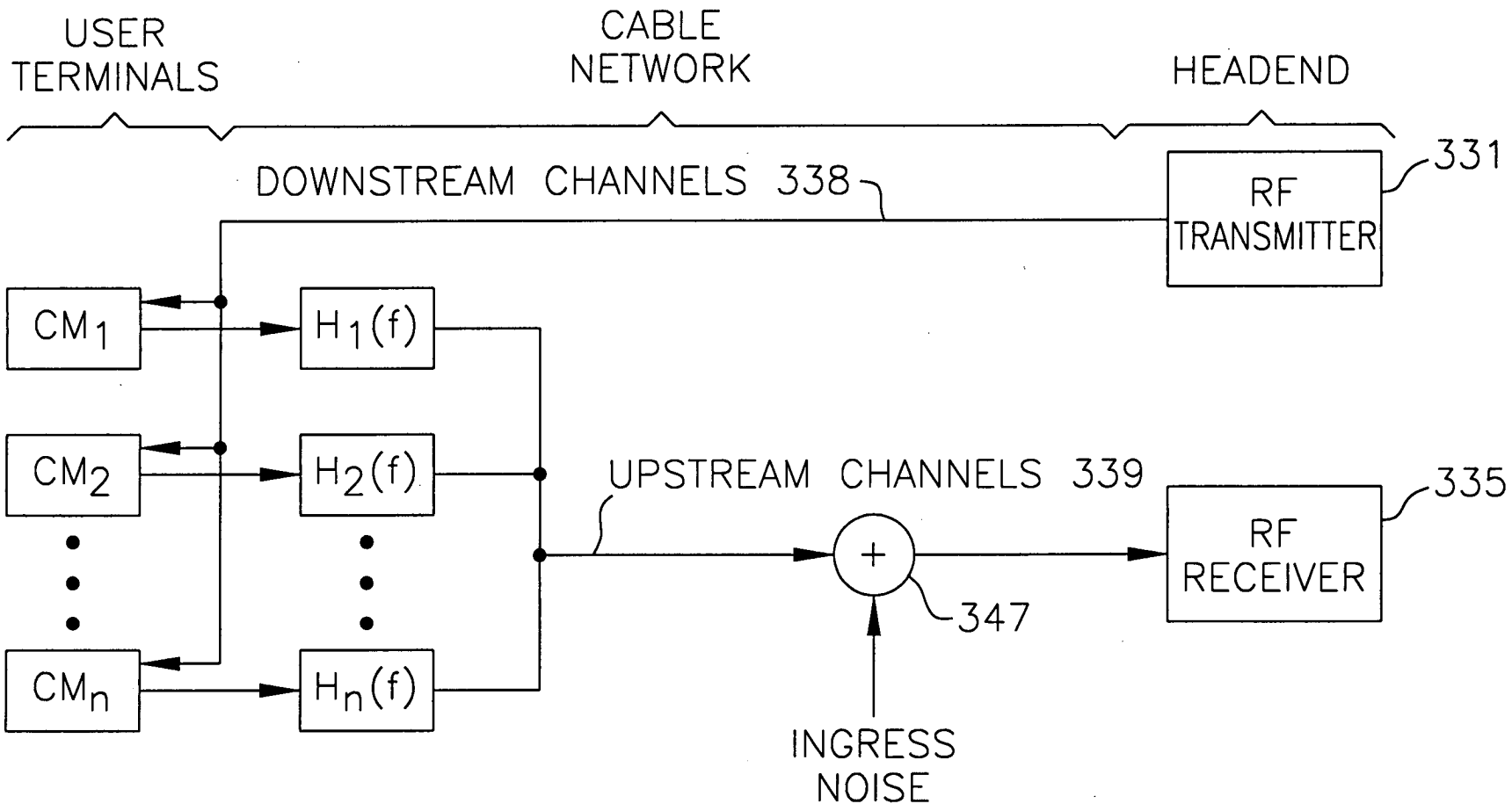

USER TERMINALS
CABLE NETWORK
HEADEND
DOWNSTREAM CHANNELS 338
RF TRANSMITTER
331
CM1
CM2
CMn
H1(f)
H2(f)
Hn(f)
UPSTREAM CHANNELS 339
+
347
RF RECEIVER
335
INGRESS NOISE

FIG.82

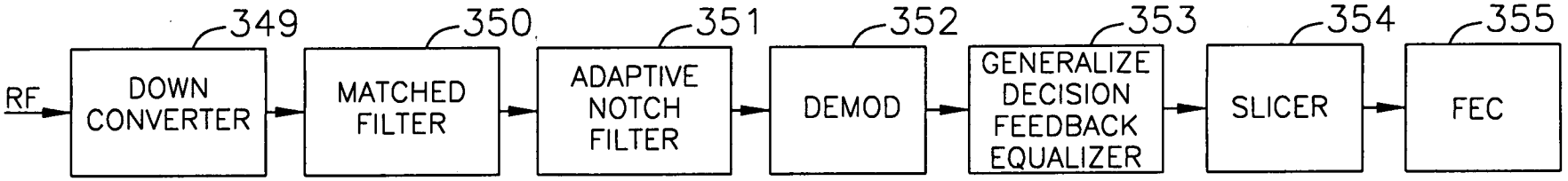

RF
DOWN CONVERTER
349
MATCHED FILTER
350
ADAPTIVE NOTCH FILTER
351
DEMOD
352
GENERALIZE DECISION FEEDBACK EQUALIZER
353
SLICER
354
FEC
355

FIG.83

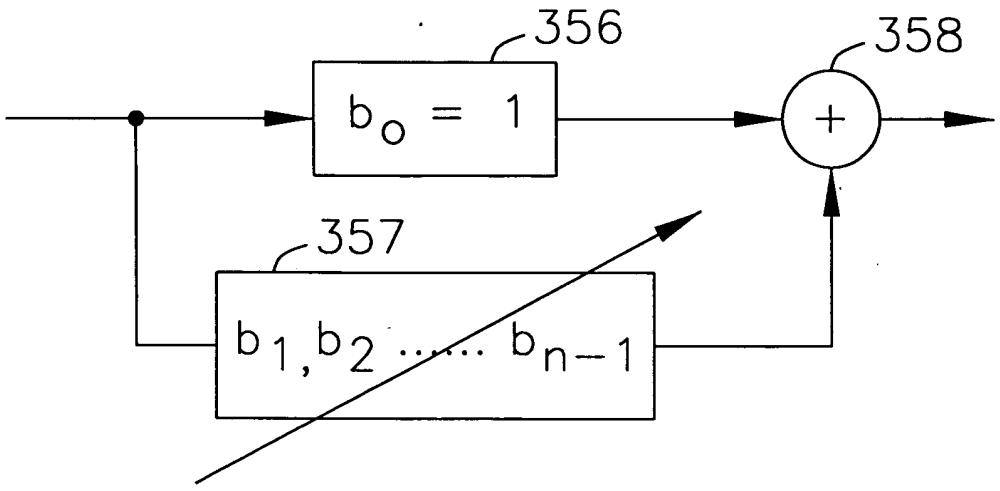

356
358
$b_o = 1$
+
357
$b_1, b_2 \ldots\ldots b_{n-1}$

FIG.84

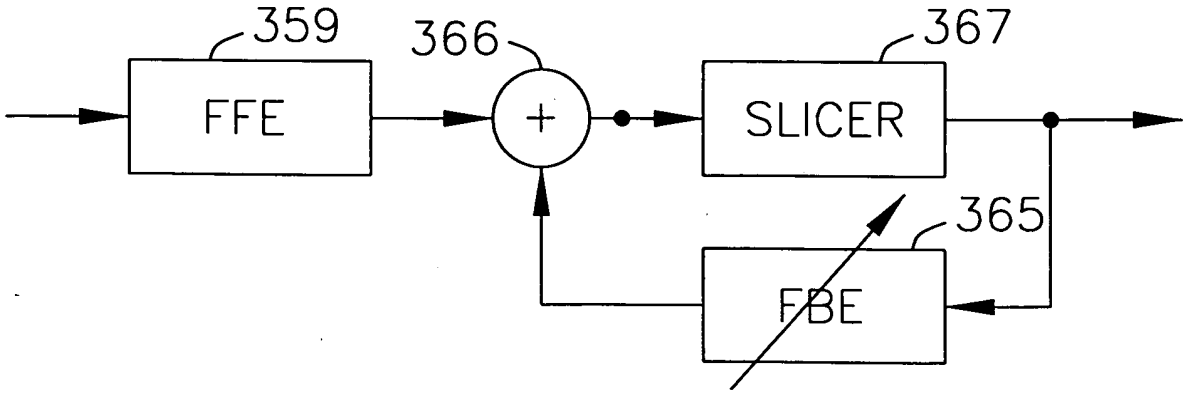

359
366
367
FFE
+
SLICER
365
FBE

FIG.85

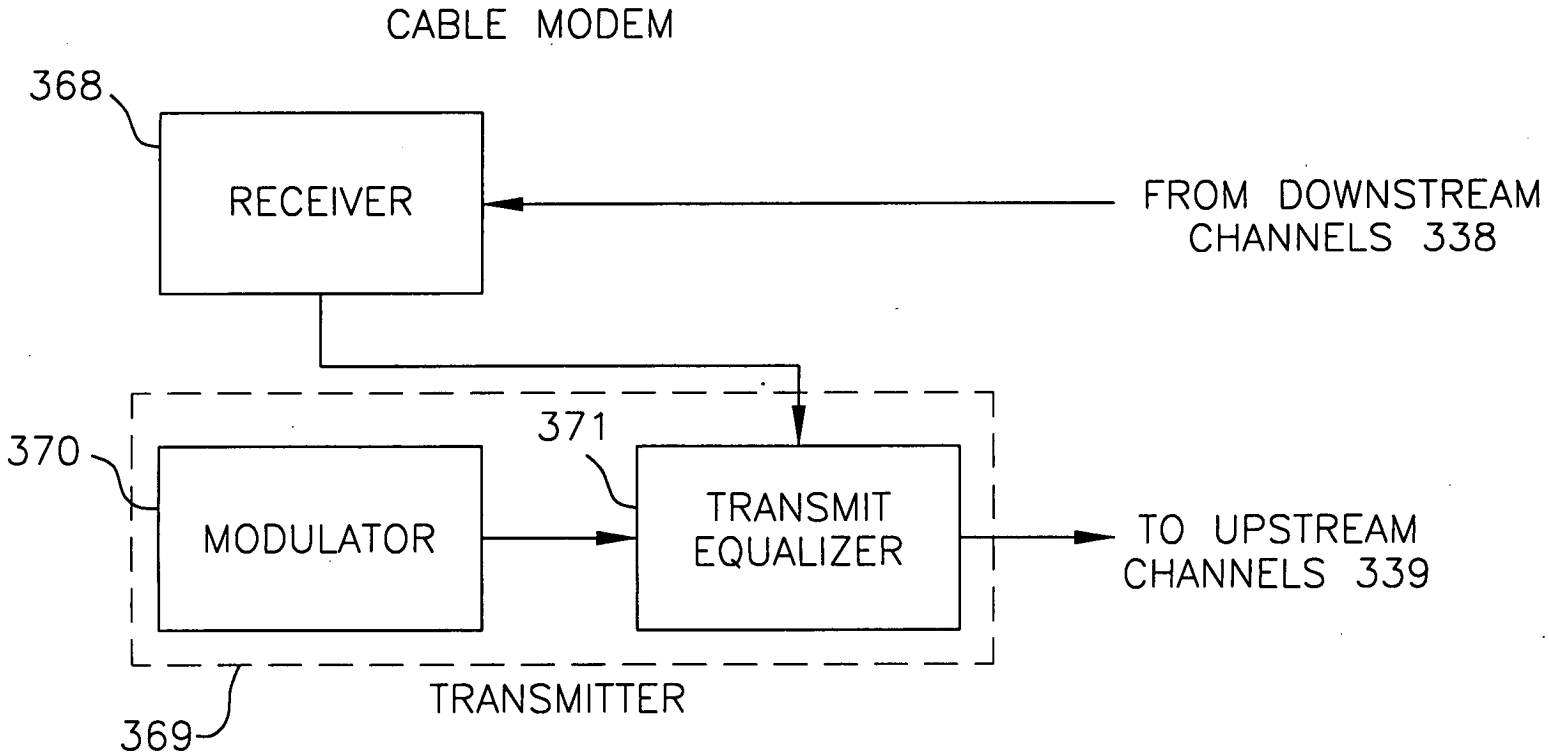

CABLE MODEM
368
RECEIVER
FROM DOWNSTREAM CHANNELS 338
371
370
MODULATOR
TRANSMIT EQUALIZER
TO UPSTREAM CHANNELS 339
TRANSMITTER
369

FIG.86

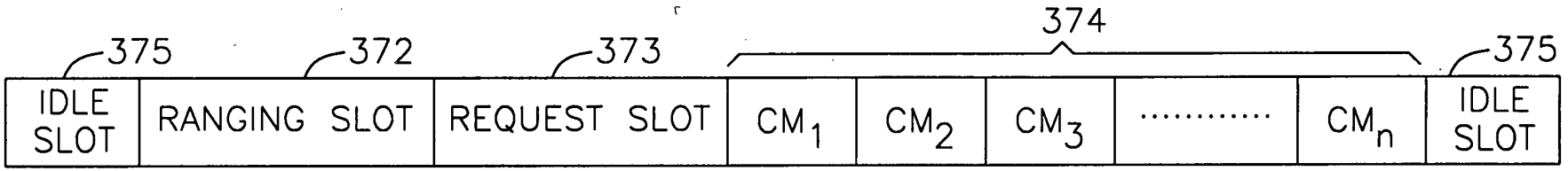

375
372
373
374
375
IDLE SLOT
RANGING SLOT
REQUEST SLOT
CM1
CM2
CM3
.....
CMn
IDLE SLOT

FIG.87

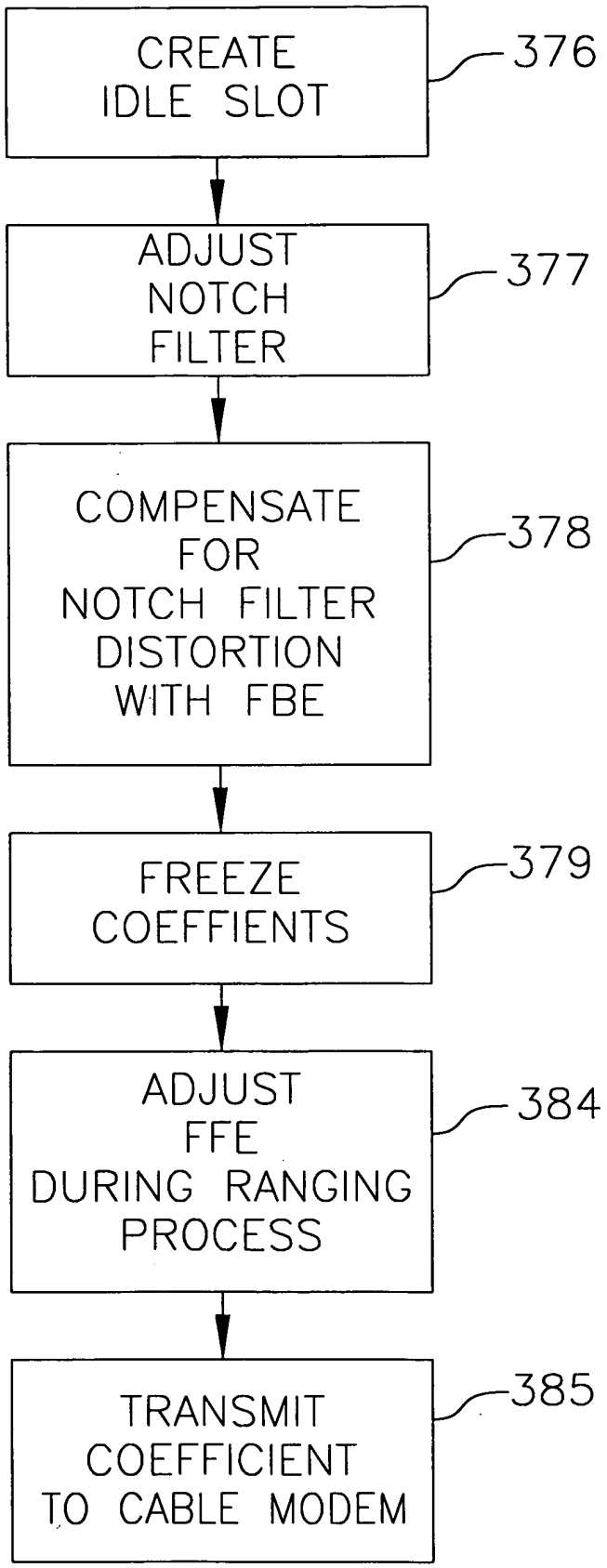

CREATE IDLE SLOT
376
ADJUST NOTCH FILTER
377
COMPENSATE FOR NOTCH FILTER DISTORTION WITH FBE
378
FREEZE COEFFIENTS
379
ADJUST FFE DURING RANGING PROCESS
384
TRANSMIT COEFFICIENT TO CABLE MODEM
385

FIG.88A

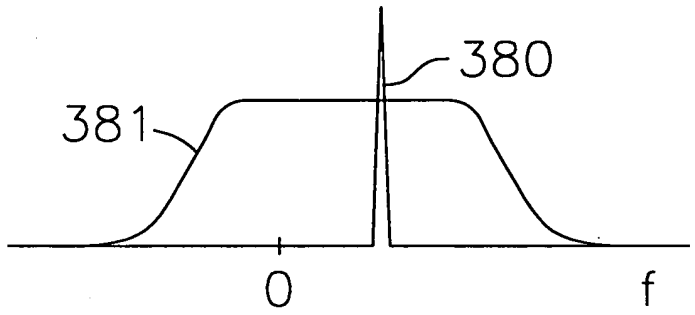


FIG.88B

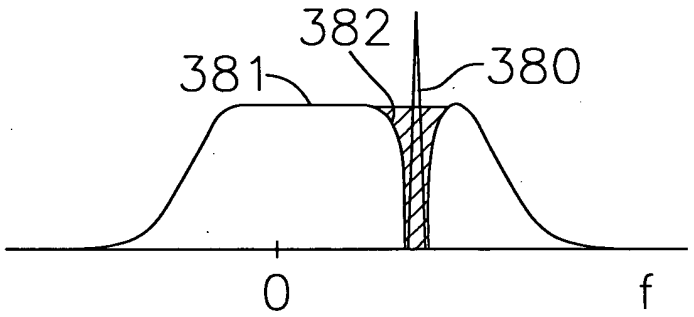


FIG.88C

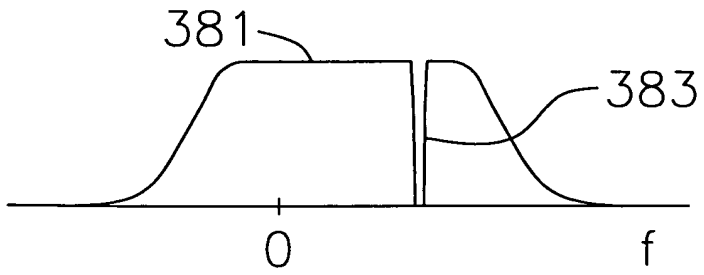


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FIG.89A

16-QAM CONSTELLATION
BEFORE NOISE REJECTION

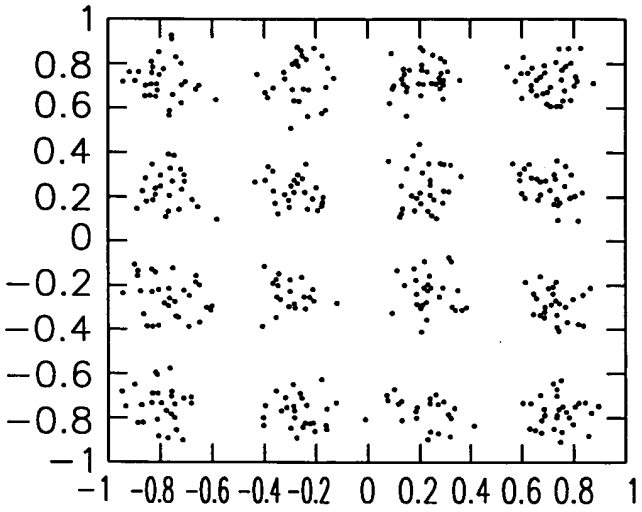

FIG.89B

16-QAM CONSTELLATION
AFTER NOISE REJECTION

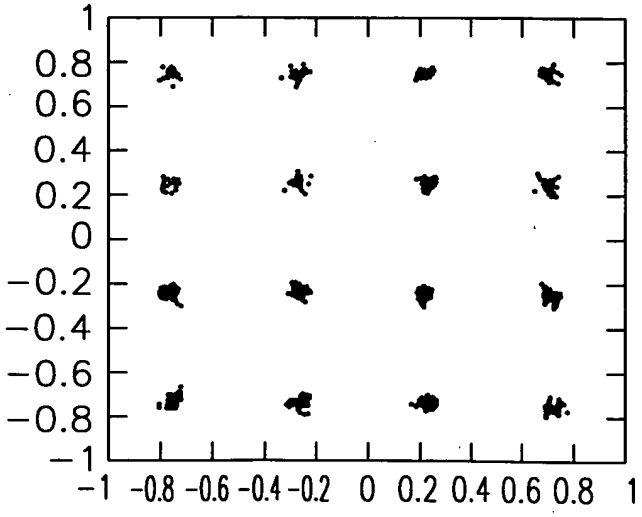

FIG. 90A

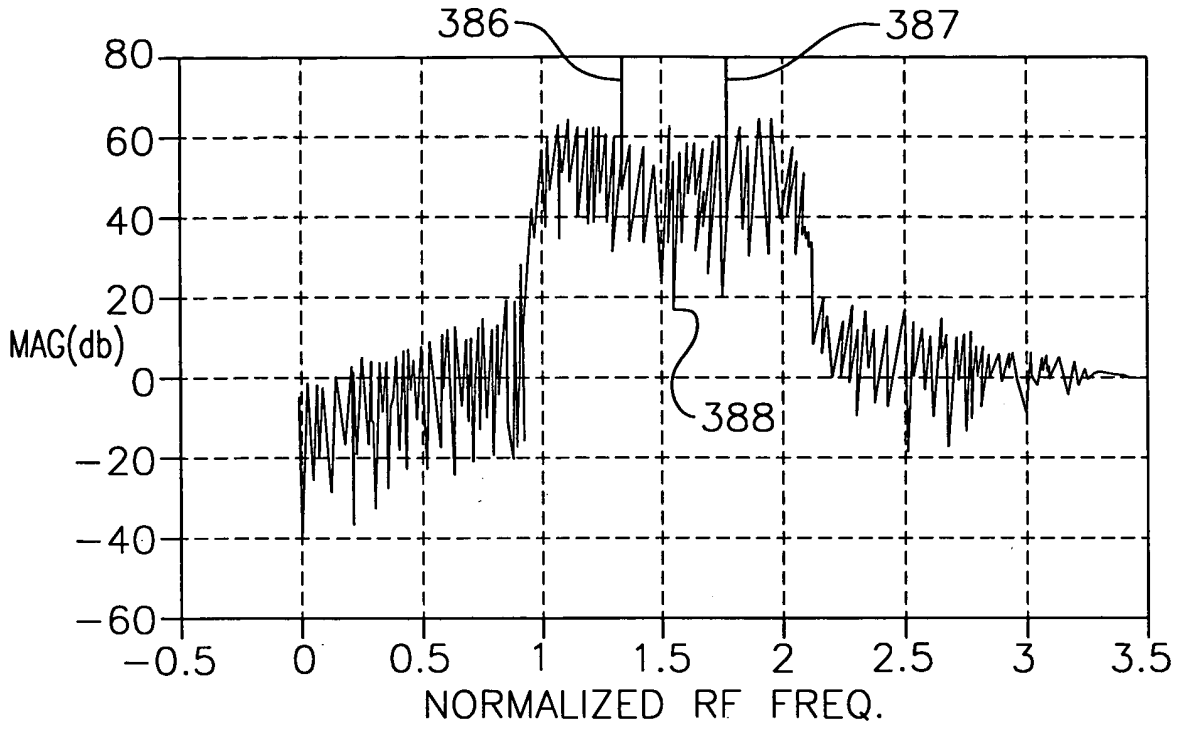
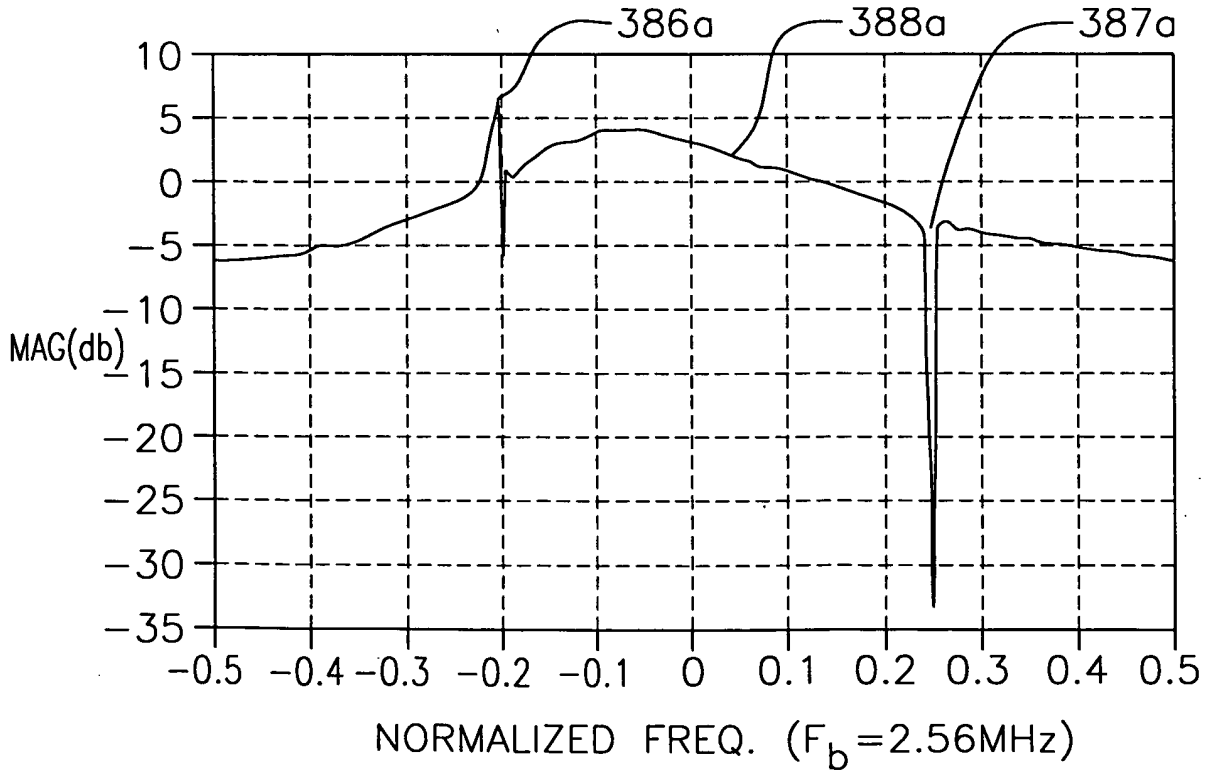
FIG. 90B